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A NEW YORK CANAL CONVENTION, called by those who favor the maintenance of the New York state canal system, was held at Syracuse, N. Y., March 26. Resolutions were adopted as follows:

The canal system of the state was the first great factor in the growth of the state of New York. During its 75 years of operation it has been the means largely of building up throughout this state the greatest line of prosperous cities and villages than can be found anywhere on this continent. It made New York city one of the greatest of seaports; it made Buffalo one of the greatest of lake ports. By this growth of population through the state, it has brought great benefits to all classes of our citizens; to the laboring man, to the farmer and to the merchant in all lines of commercial industry. In addition to its direct influences upon the prosperity of the state, it has been such a factor in controlling rates of freight that nowhere on this continent are rates of transportation by railroad and by water so moderate as in this state. The condition of the canal system of the state is most critical. The present and future commercial prosperity of the state is in great danger. Adequate improvement of the canal must be undertaken, largely increased facilities for water transportation must be secured if the state's commercial supremacy is to be maintained.

Resolved, First, that it is the sense of this convention that the commercial interests of the state will be best fostered and promoted by the construction of the 1,000-ton barge canal.

Second, That a committee of nine be appointed by the president of this convention, which shall prepare and present to the legislature and governor the further reasons for its conclusions.

A minority in the convention favored the $25,000,000 improvement recommended by Governor Odell, on the ground that a larger appropriation could not receive approval in the legislature or by popular vote.

A CANAL IMPROVEMENT BILL was prepared for submission to the legislature on April 3 under direction of Governor Odell, State Engineer Bond and other principal state officers. According to newspaper reports, it provides for the improvement of the Erie Canal and the lengthening of its locks to provide for barges of 450 tons capacity, with a draft of 8 ft. The bill provides for an issue of state bonds to the amount of $26,000,000, the issue to be approved by a popular vote, as the state constitution requires.

THE THIRD EAST RIVER BRIDGE foundation contracts for the Brooklyn tower will be readvertised as the result of a decision by Corporation Counsel Whalen of New York city. This work was described in Engineering News of March 7, 1901, and three bids for carrying it out were received, as follows: Williams & Gerstle, New York, $600,000; Bernard Rolf, $800,000, and William Hendler, $900,000. The corporation counsel threw out the last two bids because they were based upon the prevailing wages provision and were not comparable with the first bid.

THE NEW YORK & NEW JERSEY BRIDGE CO. has introduced a bill at Albany which would give it vastly extended powers. The bill provides for the incorporation of a new company which may inherit all the rights of the bridge company as chartered in 1890. It would also seemingly confer upon the new company the right to build a system of elevated railways along the North River water front, between 10th St. and 181st St., the limits set in the charter of 1890. In addition to this the company claims a franchise along all the streets ending at the North River between these limits. Under the terms of the new bill the Board of Aldermen would be compelled to grant what franchises were demanded "within a reasonable time after application therefor." The only conditions included are: That the company shall not build over a public park; must give a clear roadway of 14 ft. above streets; its motive power must be approved by the State Railroad Commission, and 3% of the earnings on both the main bridge and its approaches must be paid to the city. The bill would permit the company to lease its property to railway or other transportation companies. The officers of the New York & New Jersey Bridge Co. admit that without the power to build and operate these approaches, the main bridge across the river would be practically valueless. All previous attempts to obtain this right have failed.

THE BROOKLYN TUNNEL PROJECT, for which Mr. Albert L. Johnson is making a proposal to build by contract, with certain modifications in the plan, is thus defined in a letter to Mr. Johnson from Mr. A. E. Orr, President of the Rapid Transit Commission: The "limit of debt" for the city of New York requires that no more than $8,000,000 be appropriated for the Brooklyn extension of the rapid-transit tunnel. The law requires that the contractor for this work must lease it when completed for not less than 35 years and not more than 50 years; and during this time must pay as rental the interest upon the city bonds issued for construction, plus not less than 1% annually as a sinking fund. The contractor must also deposit $1,000,000 in cash as security; and, in addition, give a bond for construction and another bond to pay rentals. After detailing some of the experience of the Commission with undefined propositions, Mr. Orr lays down the conditions upon which the Rapid Transit Commission would consider a proposition from Mr. Johnson, especially relating to his financial ability to carry out the enterprise. Mr. Orr proposes that Mr. Johnson deposit $150,000, to be forfeited to the city if the Commission accepts Mr. Johnson's proposed extension of the project and then can not find a responsible bidder as named by Mr. Johnson. Mr. Johnson has since answered this letter, and has made new propositions, which are still unsatisfactory to the Rapid Transit Commission.

COMPRESSED AIR PREVENTED THE SUFFOCATION of 35 men shut up in the New York Rapid Transit tunnel at 181st St., by a dynamite explosion which wrecked the hoisting gear in the shaft. The shaft at this point is 131 ft. deep and the tunnel only extended about half a city block each way from the shaft. At noon, on March 21, about 50 lbs. of dynamite exploded from some unknown cause in this short section of tunnel, and one of the hoisting cages was wrecked and the other was so damaged that it would not work for some time. The thick fumes of the exploded dynamite were suffocating the 35 men then in the tunnel, and the prompt action of Engineer John G. Mullen, who at once turned on the air-compressors at full speed, alone saved them from death. The men lay for over half an hour face down in the tunnel and breathed the fresh air sent them by Engineer Mullen, while the damaged cage was being repaired. When the men were finally brought to the surface it was found that nearly all of them were burned about the face and hands, and three were bleeding profusely from lacerated wounds. Most of the clothing worn by these men was torn into shreds. The presence of mind and the quick action of Engineer Mullen alone saved the 35 men from death.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head collision between two freight trains on the Fitchburg Division of the Boston & Maine R. R., near Schaghticoke, N. Y., on March 28. Three men were killed, three seriously injured and both locomotives and many cars were wrecked. There is a double track at this point, but one track was out of use for repairs.

A COMPRESSED-AIR CAR on the 28th and 29th St. line of the Metropolitan Ry. of New York city was disabled on April 3 by the bursting of a reheating tank. The reheating tank is filled with hot water. Compressed air is expanded to the working pressure and then allowed to pass into a perforated pipe lying in the bottom of the tank, whence it bubbles up through the water and is drawn from the top of the tank for use in the engine cylinders. In the present case the perforated pipe had shaken loose from its fastenings so that it rested directly on the bottom of the tank. The constant motion and jolting of the car caused it to wear the shell until the latter became so thin that it finally gave way.

DAMAGE SUITS FOR WATER POLLUTION at and near Muncie, Ind., have been brought by farmers owning land on White River and Buck Creek. The damages asked amount to $22,000. The defendants are the Muncie Pulp Co., Consumers' Paper Co., and West Muncie Strawboard Co.

SEWAGE DISPOSAL in the Passaic Valley may possibly be investigated at once, notwithstanding the failure of the recent attempts to secure legislation creating a sewerage district. It is informally announced that Governor Voorhees will allow $8,000 to be used from the State contingent fund for a preliminary study of the problem by the State Sewerage Commission. Mr. Boyd McClean, Fuller Bldg., Jersey City, is secretary of the commission.

THE TENEMENT HOUSE COMMISSION had a public hearing on March 25 in connection with the bill to be presented by the Commission at Albany. The chief argument of the opposition to the bill was: That the department proposed would cost the city nearer $500,000 than $250,000 annually; and that the enforcement of the law, as to light and air, would leave less ground space to be built upon and diminish by one-third the value of building sites. Both of these statements were denied by members of the commission and by architects. The City and Suburban Homes Co. is now building houses in substantial compliance with the terms of the proposed law, and it finds these structures profitable. The chief purpose of the new law is to concentrate responsibility now divided between the Health, Fire and Police Departments of New York; to enforce existing regulations, and to frame and enforce new regulations better caring for the health and comfort of the people now living in the 82,000 tenements in the city of New York.

THE UNITED STATES STEEL CORPORATION has added another quarter billion dollars to its capitalization, which brings the total authorized issue of its securities to the gentle sum of $1,404,000,000. This additional capitalization provides for the acquisition of the Lake Superior Consolidated Iron Mines with its issues of $29,887,448 in stock and $5,995,000 in bonds; the American Bridge Co., with its $70,000,000 stock; the outstanding interest in the Oliver Iron Mining Co., and the Pittsburg Steamship Co. not already owned by the Carnegie Co.; and the Rockefeller lake steamers. Among the names of the directors of the corporation are the following, well known in engineering circles: Chas. M. Schwab, Henry C. Frick, E. C. Converse, Percival Roberts, Abram S. Hewitt, Clement A. Griscom. Mr. Schwab is to be the President.

EXPORTS OF IRON AND STEEL MANUFACTURES of the United States continue to increase, says the Treasury Bureau of Statistics. For the eight months ending Feb. 1, 1901, the value of this export is $81,553,132, as compared with $18,823,384 for the corresponding period in 1890-91. The figures for February, 1891, are 6½ millions in excess of the same period in 1899-1900. Iron and steel manufactures now form 8% of the total domestic exports, while they made up only 3% in 1891. Steel rails amount to $6,889,079 in the exports of the present fiscal year, and builders' hardware to almost as much; electrical machinery and billets and ingots amount to $3,777,673 and $3,067,372 respectively; sewing machines and locomotives are almost the same in value at $2,827,652 and $2,828,165; and steel bars, structural steel and iron and wire figure as $2,637,813, $2,286,287 and $2,499,946 respectively. Typewriters amount to $1,785,821, and pumps and pump machinery to $1,497,136. Wire nails, printing presses, firearms, bar iron, stoves and scales make up the chief remaining items, with values ranging from $824,522 for the first, to $358,892 for the last item.

THE CRAGIN SHIP-YARD AND DRY-DOCK PROJECT, to be located on reclaimed ground between Bedloe's and Ellis Islands, in New York harbor, is not favorably received by the War Department. The project seems to include an attempt to seize a large area under water in New York and to convert it into a valuable inland, with 1½ miles of water front in that harbor. The Riparian Commission of New Jersey has granted rights to Mr. Edward E. Cragin, and asks the New York Harbor Board to modify its bulkhead and pier lines in such manner as to make the concession valid. The War Department does not recognize the rights of New Jersey beyond the pier-head line on the mainland, as the state of New York exercises jurisdiction in both the North River and the Kill Von Kull up to this New Jersey pier line. The proposed island would thus be in New York's territory, and legislation at Albany would be necessary to authorize its construction. The War Department objects to the multiplication of promiscuous islands in the busiest harbor in the United States. The project was given a hearing before the New York Harbor Line Board on March 21, when Mr. Cragin stated that it was the purpose of the syndicate to locate its dry-dock at the north end of the island to be made, and this dock was to be 1,050 ft. long, so that it would accommodate the largest liner coming to this port. The U. S. Treasury Department, through its representative, Lieut. Frey, said that it was not opposed to the building of the dock—provided, that a clear channel, 500 ft. wide, was left between the property and the west wall of Ellis Island. Chief Engineer Brown, of the Pennsylvania R. R. Co., opposed the Cragin plans: he stated that his company proposed to expend $8,000,000 in harbor improvements on the Jersey shore. The plans called for filling in the shallows; building bulkheads, and constructing four piers, 125 and 240 ft. wide and 3,000 and 4,000 ft. long, with four transfer bridges. Mr. Brown stated that the Cragin plans would seriously interfere with these proposed improvements. The owners of real property on the shore, between Ellis and Bedloe Islands, favored the Cragin plan. It was stated that the New Jersey Riparian Commission was to obtain $25 per acre for all land under water required by the Cragin syndicate.

THE EAST BOSTON TUNNEL EXTENSION OF THE BOSTON SUBWAY.

The proposition to extend the Boston subway to East Boston by means of a tunnel under the harbor dates back to 1894, when work was first started on the subway, but it was not until the spring of 1900 that the various legal complications which had arisen from one source and another were finally adjusted so that construction could be commenced. The contract for the first section of the tunnel was awarded on April 24, 1900, and work was begun on May 5, 1900. On June 28, 1900, the contract for the second section of the tunnel was awarded and work was begun on Aug. 13, 1900. Construction is now in active progress on both of these sections, and as the character of the work and the methods of executing it are particularly interesting, we present here a description of its essential features. For the information from which this description is prepared we are indebted to the last Annual Report of the Boston Transit Commission, and to Mr. Howard Carson, M. Am. Soc. C. E., Chief Engineer of the commission.

FIG. 1.—SKETCH MAP SHOWING ROUTE OF EAST BOSTON TUNNEL AND ITS CONNECTIONS WITH THE SUBWAY, ELEVATED AND SURFACE RAILWAYS OF BOSTON, MASS.

Briefly described, the East Boston Tunnel will run from a connection with the present subway, near Scollay Square, to a terminus at Maverick Square, in East Boston, a distance of about 1¼ miles. The relation of the new tunnel line to the original subway, and to the elevated and surface railways of Boston, is clearly shown by Fig. 1. Fig. 2 is a profile of the tunnel line.

In the earlier discussions and studies of the East Boston Tunnel it was assumed that the tunnel for a length of upward of 3,000 ft. under and near the harbor, would consist of two narrow tubes, each of about 16 ft. internal diameter. After careful study, however, the commission concluded that although a wide tube would be more costly, and would have less favorable grades than twin narrow ones, it would conduce more to the comfort of passengers, would be much more satisfactory to the public, and would be more in accordance with the work previously done by the commission, and therefore, a wide single tube tunnel was adopted, having an internal clearance of about 23 ft. A comparison of the adopted section with the sections of several other large tunnels of similar character is made in Fig. 3.

The cross-section of the tunnel having been decided upon, attention was turned to the selection of a lining best suited to the conditions. Previous tunnels of a similar character had been built with cast-iron linings, and in most of the earlier studies for the East Boston Tunnel a similar construction was contemplated. The great rise in the cost of iron which took place about 2½ years ago, however, led to a study of concrete as a substitute. In reference to this question, Mr. Carson, in his report for the fiscal year of 1900, says:

> Concrete has been employed as a building material for centuries and owing to the improvement in Portland cement its use during the last two or three decades has grown very rapidly and appears likely to continue to increase for many years to come. There has also been considerable experience as to advantageous methods of using steel and iron in connection with concrete so as to form emonomical and effective combinations. Segments of cast iron such as were used in the tunnels referred to above have important advantages. They can be bolted together so as to form the walls of the tunnel in a manner comparatively simple and easy and in such a way as to interfere but little with the operations of excavation. The full strength of the walls so built is to be had immediately and they form excellent supports for the hydraulic jacks to push against in moving the tunneling shield forward. They have a further advantage in very wet ground that they can be calked so as to leak but little.
>
> Concrete walls must necessarily be made thicker than cast iron ones; they must be built on centering, which occupies appreciable space; difficulties requiring ingenuity to overcome exist in the matter of keying up, etc.; shrinkage cracks are to be expected through which in wet ground leakage may occur unless adequately provided against; the full strength of the concrete is not obtained until more than a year after it is made, and while the necessary strength is being reached centers and bracing must be kept in place. About one-half the full strength of the concrete, however, is reached in less than one month, and in general, centers and bracing need not remain in place longer than that. In the matter of durability concrete has rather more chances in its favor than cast iron, and in the matter of cost the difference in favor of concrete where it is feasible to use it is very great. Shrinkage cracks in the tunnel can be wholly or partially closed, and for a considerable portion of the length of the East Boston tunnel and perhaps for nearly all of it the walls will be surrounded by such compact and excellent clay that a great amount of leakage is not to be expected.

It is proposed, therefore, in the East Boston Tunnel to make use of concrete to such an extent as the conditions were developed shall warrant. It is also proposed to combine steel with the concrete to such an extent as shall prove necessary and in such a manner as shall be effective and economical, and as shall be found convenient in progressing with the work. Cast-iron segments bolted together, combined with steel ribs, may be used where the ground is such that a great amount of leakage is apprehended, or where for any reason they may be desirable.

The profile of the tunnel is shown by Fig. 2. Some 200 borings were made along this profile to determine the character of the material through which the tunnel would pass. These borings varied in depth from 20 to 60 ft.

The first section of the tunnel work contracted for was the portion of the line between Maverick Square and Lewis St., in East Boston, the contractors being the National Contracting Co., of New York, and the work being in charge of Mr. John E. Palmer, Assistant Engineer for the commission. The structure of this section of the line is for two electric railway tracks, and consists of 139 ft. of open incline and 680 ft. of wide arch subway. The sidewalls of the incline are of concrete faced with granite, and surmounted by a granite coping. Granite also surrounds the portal. Nuts and washers are embedded in the masonry to admit the use of steel tie-rods for increasing the strength of the roof if deemed desirable. This section is at a grade of 5% for its whole length, and at its lower end the bottom of the masonry invert is about 39 ft. below the surface of the street. All of the excavation has been done by open cut. The excavation for the incline in Maverick Square was done without timbering the trench and the earth was shoveled into carts. For the remainder of the section the trench was braced for its full width; the first 10 ft. in depth of the excavation was done by shoveling the earth into carts, but the remainder of the material was removed by means of a cableway.

In preparing to put in the masonry for the covered portion, the bottom of the excavation was graded and three thicknesses of tarred felt were laid. They were laid so as to lap 6 ins., and were thoroughly pitched together, and the surfaces were mopped until entirely covered. When the pitch had hardened sufficiently the concrete invert was put in and 6-in. back walls were carried up a convenient distance, the sheeting being removed and the trench braced as necessary. The back walls

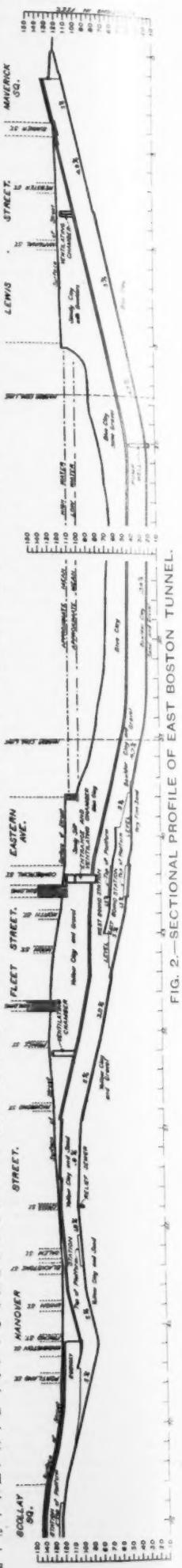


FIG. 2.—SECTIONAL PROFILE OF EAST BOSTON TUNNEL.

were plastered with a rich Portland cement plaster, and against this the main wall was built. These operations were completed until the walls were completed to the springing line of the arch. Wooden centers were used, and the work on each section of the arch was carried on continuously until its completion. The arch was allowed to set about twelve hours, when the outside lagging was removed and the arch plastered so as to join the plastering of the back walls. A 4-in layer of concrete was put on above the plaster so as to protect it from future excavators; the plaster being roughened by a corrugated roller, made for the purpose, to assure a bond with the following layer of concrete. So far as was practicable the excavation, laying of tarred felt, putting in concrete inverts, walls and arches has been in 12-ft. sections, one operation closely following another. The centers were struck in ten days in some portions of the work, but in most cases they were allowed to stand 30 days. Backfilling was begun as soon as the lagging was removed from the outside of the 4-in. layer of concrete, and this filling was brought in buckets by means of the cableway from the point where excavation was going on. Fig. 4 shows typical cross-sections of the first section of the tunnel, and Fig. 5 is a view showing the nature of the concrete lining.

The second section of the tunnel work, the contract for which was awarded to the Boston Tunnel Construction Co., extends from the end of the first section in East Boston under the harbor, and to a point in Boston a little less than half a mile from Scollay Square. The total length of the section is 4,430 ft. The thickness of the roof of earth over the outside of the arch of the tunnel under the harbor will be from 16 to 18 ft., above which in the deepest part of the harbor will be about 35½ ft. of water at mean low tide. The structure of this portion of the tunnel will provide for a double track electric railway. The portion under the harbor about 2,250 ft. long will have inside dimensions of 23 × 20½ ft., and walls 33 ins. thick and upwards. The grades of the various sections of the line are shown by Fig. 2. The work on this section includes pump wells and chambers under the harbor and ventilating chambers on each side of the harbor. Ventilation of that portion of the tunnel under the harbor will be effected by means of a segmental duct of about 45 sq. ft. area in the top of the tunnel. Near the middle of the harbor this duct will communicate with the tunnel underneath by a door, while its shore ends will open into ventilating chambers through which the air can be drawn out. Fig. 6 shows a cross-section of the second section of the tunnel, and Fig. 7 gives some details of the cast-iron segments and steel ribs for use in water-bearing sand and gravel.

The method of construction adopted for this section of the tunnel calls for the use of a roof shield. The construction of this shield is shown by the drawings of Figs. 8 and 9. In his specifications for this shield, Mr. Carson said:

> The contractor may use roof shields following in a general way the method used on Section 6 of the Boston Subway (Eng. News, June 24, 1897), or he may make use of shields enveloping a larger proportion of the cross-section of the tunnel. The shields used must have ample strength and accurate shape and for constructing the tunnel under the harbor shall be so made that any portion of the front ends can be strongly and promptly bulkheaded with plates of metal if prudence should so require. The bulkhead plates shall be so arranged that each or all can be readily removed or adjusted in new positions by bolts and screws. The shields must be fitted with hydraulic cylinder presses of ample number and capacity for overcoming the resistance of the earth to the forward movement of the shield. The rear portion of the presses may react against heavy lagging or against the properly braced ribs of the centering on which the exterior wall of concrete is built. If at any portion of the tunnel the wall shall be built of iron castings the presses will at such point react against said iron plates which must be braced between their flanges if necessary. It shall be arranged by auxiliary hydraulic presses or otherwise so that when the forward movement of the shield takes place concrete will be tightly pressed into the space left vacant by the tail end of the shield.

As will be seen by referring to our issue of June 24, 1897, the present shield envelopes a considerably larger segment of the tunnel section than did the shield used on Section 6 of the original subway. It was designed by Mr. C. R. Perry, of Waltham, Mass., for the contractors, and was built by the James Russell Boiler Works Co., of South Boston, Mass.

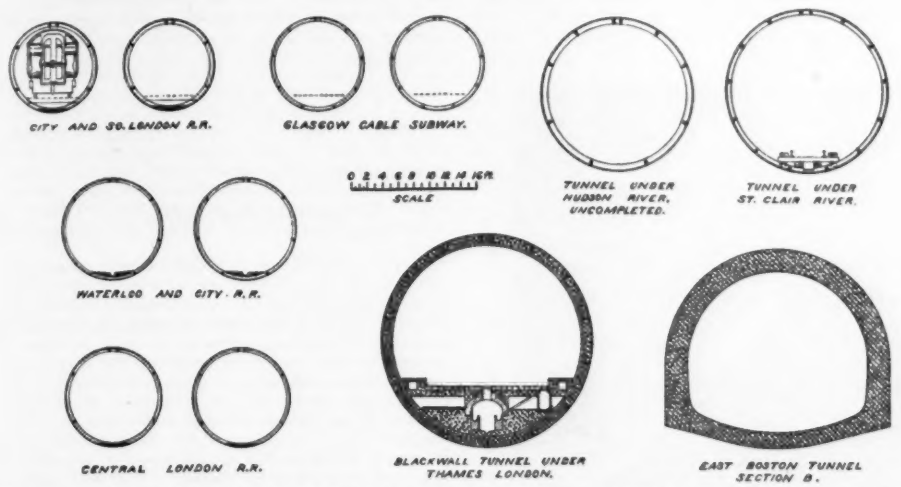

CITY AND SO. LONDON R.R.
GLASGOW CABLE SUBWAY.
SCALE
TUNNEL UNDER HUDSON RIVER, UNCOMPLETED.
TUNNEL UNDER ST. CLAIR RIVER.
WATERLOO AND CITY R.R.
CENTRAL LONDON R.R.
BLACKWALL TUNNEL UNDER THAMES LONDON.
EAST BOSTON TUNNEL SECTION B.

FIG. 3.—SKETCH SHOWING SIZE OF EAST BOSTON TUNNEL COMPARED WITH OTHER SUBMARINE TUNNELS.

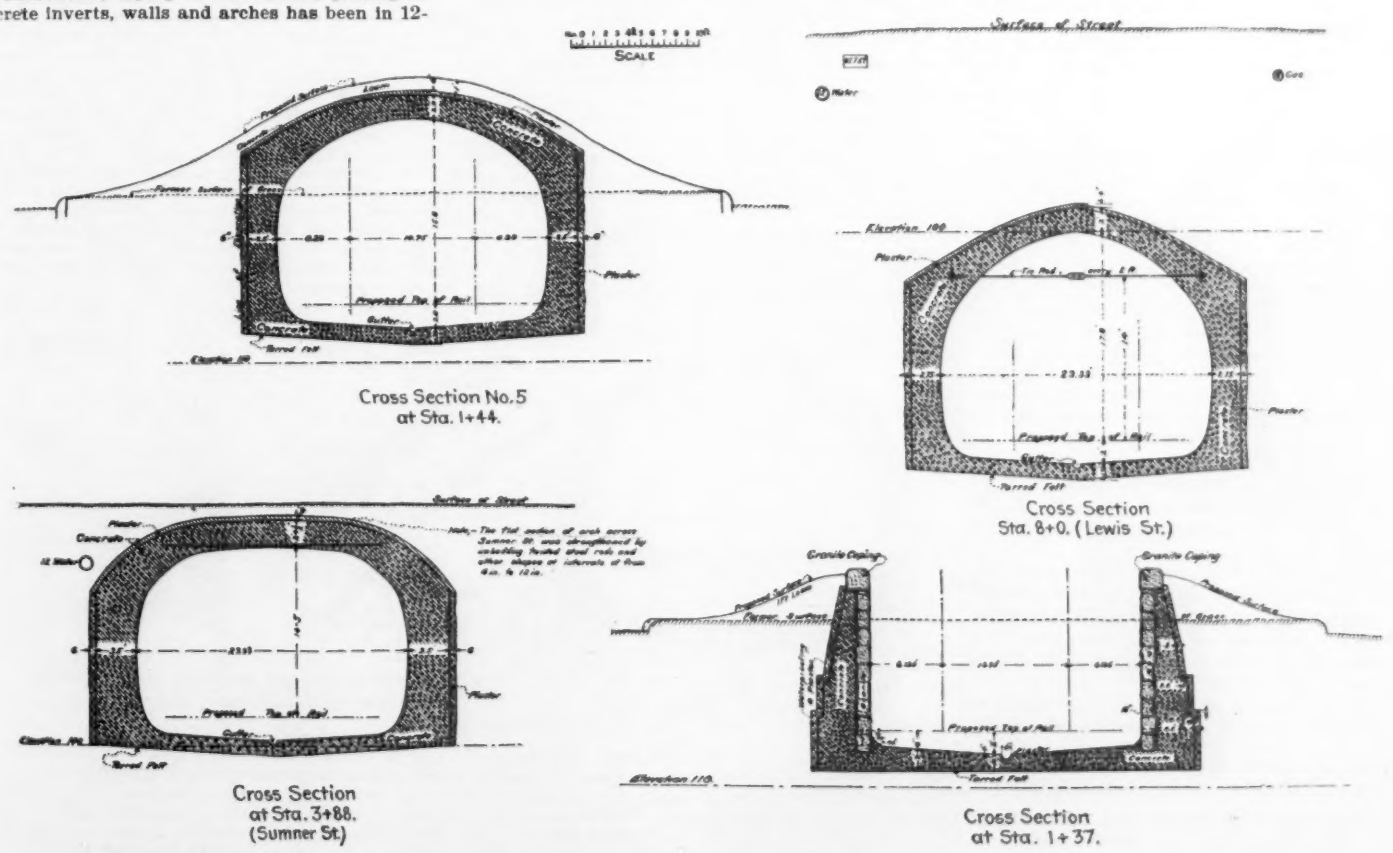

SCALE
Cross Section No. 5 at Sta. 1+44.
Cross Section Sta. 8+0. (Lewis St.)
Cross Section at Sta. 3+88. (Sumner St.)
Cross Section at Sta. 1+37.

FIG. 4.—TYPICAL SECTIONS OF OPEN CUT AND SUBWAY APPROACH TO HARBOR SECTION OF EAST BOSTON TUNNEL.

FIG. 2.—SECTIONAL PROFILE OF EAST BOSTON TUNNEL.

WATER-TUBE BOILERS IN THE BRITISH NAVY.

A report has just been presented by the expert commission appointed last August by the British Government to consider a change in the type of water-tube boiler to be used in the British naval vessels. The following is a brief statement of the events which culminated in the appointment of this commission:

Some five years ago, the advantages claimed for water-tube boilers in naval service and the difficulties experienced in the use of Scotch boilers under forced draft led the British Admiralty to adopt the Belleville boiler for a number of its vessels then under construction. The Belleville boiler is a French invention, and was at that time in use in several French war vessels, being then, in fact, the only water-tube boiler which had been used on any considerable scale in naval vessels. Following the lead of England, various other navies adopted Belleville boilers, and they are now in more extensive use on war vessels than any other water-tube boiler.

FIG. 5.—VIEW SHOWING CONCRETE LINING AND ARCH CONSTRUCTION EAST BOSTON APPROACH TO EAST BOSTON TUNNEL.

From the time of its introduction, however, great difficulties have been experienced with the Belleville boiler in the British navy. Accidents have occurred on some vessels involving loss of life, and even endangering the safety of the vessel. Moreover, it has become apparent that many vessels equipped with these boilers would have been seriously handicapped had their services been required in war. It may also be added that the adoption of a French invention in the English naval service has been seriously resented by Englishmen generally, and some of the opposition to the Belleville boiler may probably be ascribed to this source.

All these causes brought about, in August last, the appointment of a commission of expert engineers, who were instructed to report as to whether the Belleville boiler should be rejected, and if so, what should be adopted in its place. The report of the Commission is as follows:

1. The committee are of opinion that the advantages of water-tube boilers for naval purposes are so great, chiefly from the military point of view, that, provided a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in his Majesty's Navy than the cylindrical type of boiler.

2. The committee do not consider that the Belleville boiler has any such advantage over other types of water-tube boilers as to lead them to recommend it as the best adapted to the requirements of his Majesty's Navy.

3. The committee recommend: (a) As regards ships which are to be ordered in the future: That Belleville boilers be not fitted in any case. (b) As regards ships recently ordered, for which the work done on the boilers is not too far advanced: That Belleville boilers be not fitted. (c) As regards ships under construction, for which the work is so far advanced that any alteration of type of boiler would delay the completion of the ships: That Belleville boilers be retained. (d) As regards completed ships: That Belleville boilers be retained as fitted.

4. In addition to the Belleville type of boiler, the committee have had under consideration four types of large straight-tube boilers which have been tried in war vessels, and are now being adopted on an extended scale in foreign navies. These are: (a) The Babcock & Wilcox boiler; (b) the Niclausse boiler; (c) the Dürr boiler; (d) the Yarrow large tube boiler. (a) and (b) have also been tried in our own navy with satisfactory results, and are now being adopted on a limited scale. If a type of water-tube boiler has to be decided on at once for use in the navy, the committee suggest that some or all of these types be taken.

5. The committee recommend that the completion of the two sloops and the second-class cruiser fitting with Babcock & Wilcox boilers, and the sloop and first-class cruiser fitting with Niclausse boilers, be expedited, in order that the value of these types of boilers for naval purposes may be ascertained at the earliest possible date. This is especially important, as the Babcock & Wilcox boiler adopted in the ships under construction differs materially from the Babcock & Wilcox boiler as fitted in the "Sheldrake."

6. The committee recommend that boilers of the Dürr and of a modified Yarrow type be made and tested at the earliest possible date, under their supervision, with a view of aiding the selection of one or more types of water-tube boilers for use in his Majesty's ships. For this purpose the committee suggest that two cruisers, not smaller than the "Medea" class, with vertical triple-expansion engines, be placed at their disposal, and that they be empowered to order at once Dürr and Yarrow boilers to be fitted to them, and to order also the removal of their present boilers and the necessary modifications to their machinery, so that the performance of the types of boilers named may be definitely ascertained under ordinary working conditions from extended seagoing trials. The committee suggest vessels not smaller than the "Medea" class, because the evidence before them shows that it has been difficult to draw from torpedo gunboat trials conclusions fully applicable to larger vessels.

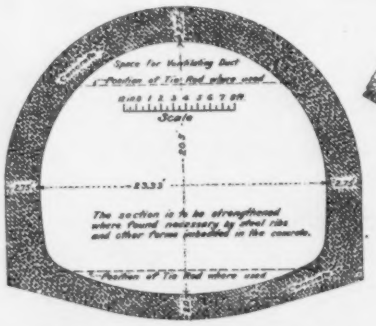

Space for Watching Duct
Position of Trial Pipes used
Scale
The section is to be strengthened where found necessary by steel ribs and other forms imbedded in the concrete.

Fig. 6.—Cross-Section of Harbor Section of East Boston Tunnel.

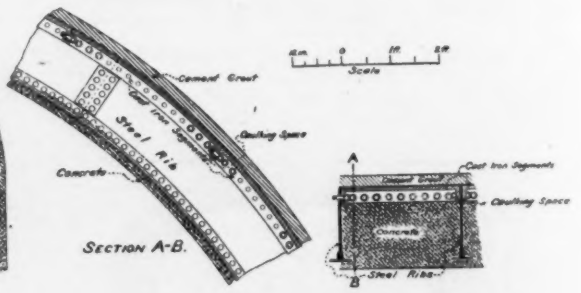


Fig. 7.—Detail of Cast-Iron Segments and Steel Ribs for Use in Water-Bearing Material.

7. With reference to paragraph (1), evidence has been given before the committee to the effect that three most important requirements from the military point of view are: (a) Rapidity of raising steam and of increasing the number of boilers at work. (b) Reduction to a minimum of danger to the ship from damage to boilers from shot or shell. (c) Possibility of removing damaged boilers and replacing them by new boilers in a very short time and without opening up the decks or removing fixtures of the hull. These requirements are met by the water-tube boiler in a greater degree than by the cylindrical boiler, and are considered by the committee of such importance as to outweigh the advantages of the latter type in economy of fuel and cost of upkeep.

8. The opinion expressed by the committee in paragraph (2) has been formed after a personal examination of the boilers in a number of his Majesty's ships, including the "Diadem," "Niobe," "Europa," "Hermes," "Powerful," "Furious," and "Ariadne"; upon the statements of defects which have been placed before them; and the evidence of the chief engineers of those vessels and other officers on the engineering staff of the Admiralty and Dockyards. This evidence is being printed, and will be forwarded when ready.

9. The committee consider the following points in relation to the construction and working of the Belleville boiler to constitute practical objections of a serious nature: (a) The circulation of water is defective and uncertain, because of the resistance offered by the great length of tube between the feed and steam collectors, the friction of the junction boxes, and the small holes in the nipples between the feed collector and the generator tubes, which also are liable to be obstructed, and may thus become a source of danger. (b) The necessity of an automatic feeding apparatus of a delicate and complicated kind. (c) The great excess of the pressure required in the feed pipes and pumps over the boiler pressure. (d) The considerable necessary excess of boiler pressure over the working pressure at the engines. (e) The water gages not indicating with certainty the amount of water in the boiler. This has led to serious accidents. (f) The quantity of water which the boiler contains at different rates of combustion varying, although the same level may be shown on the water gages. (g) The necessity of providing separators with automatic blow-out valves on the main steam pipes to provide for water thrown out of the boilers when speed is suddenly increased. (h) The constant trouble and loss of water resulting from the nickel sleeve joints connecting the elements to the feed collectors. (i) The liability of the upper generator tubes to fail by pitting or corrosion, and, in economizer boilers, the still greater liability of the economizer tubes to fail from the same cause. Further: (k) The upkeep of the Belleville boiler has so far proved to be more costly than that of cylindrical boilers; in the opinion of the committee this excess is likely to increase materially with the age of the boilers. (l) The additional evaporating plant required with Belleville boilers, and their greater coal consumption on ordinary service as compared with cylindrical boilers, has hitherto nullified to a great extent the saving of weight effected by their adoption, and, in considering the radius of action, it is doubtful whether any real advantage has been gained. The committee are not prepared without further experience to say to what extent this may not apply to other types of water-tube boilers.

10. At the time the Belleville boiler was introduced into the navy in the "Powerful" and "Terrible," it was the only large tube type of water-tube boiler which had been tried at sea on a considerable scale under ordinary working conditions. The committee therefore consider that there was justification for then regarding it as the most suitable type of water-tube boiler for the navy.

11. To obtain satisfactory results in the working of the Belleville boiler, in fact of the defects named in paragraph (9), more than ordinary experience and skill are required on the part of the engine-room staff. It appears, however, from the evidence placed before the committee, that the engineer officers in charge of Belleville boilers have not been made acquainted with the best method of working the boilers, and that which experience has shown

to be most effectual in preventing the pitting and corrosion of tubes.

12. In view of the rapid deterioration of economizer tubes in several vessels, the committee have specially considered whether the extra power per ton of boiler at high rates of combustion, obtained by the use of economizers has not been too dearly purchased. The evidence before them indicates that at the lower and more usual rates of combustion the "Powerful" type of boiler has given results as satisfactory as the economizer type. It is at the same time less complex, and free from the special risks of tube deterioration which have proved so serious in many cases, notably in the "Europa." They therefore recommend, for ships under construction, that the non-economizer type should be reverted to where practicable, with the tubes raised higher above the firebars to increase the combustion space, and that where possible the steam collectors should be made larger, and more accessible internally.

13. The evidence before the committee shows that a large proportion of the coal expended in the navy is used for distilling and other auxiliary purposes, in harbor as well as at sea. For such purposes the cylindrical boiler is, in the opinion of the committee, more suitable and economical than any type of water-tube boiler. They recognize that there are objections to fitting cylindrical and water-tube boilers in combination, but they believe that those drawbacks would be more than compensated for by resulting advantages, observing that the cylindrical boilers could be used for supplying distilled water in case of failure or insufficiency of the evaporating plant. On these grounds it is considered desirable that all the new vessels of large power should be provided with cylindrical boilers to do the auxiliary work.

14. The committee have to state, for the information of their lordships, that a series of comparative trials for determining economy in coal and water consumption were arranged in October, 1900, for H.M.S. "Minerva" and "Hyacinth." The trials of the former ship commenced on Jan. 7, as soon as she was ready, but were temporarily interrupted by recent events. The committee, are, however, now informed that the "Minerva" will not be again available until after March 2, and that the "Hyacinth" will not be ready to commence her trials until the first week in April. It is proposed to include in these trials a full-speed run for both ships from Portsmouth to Gibraltar and back.

Compton Domvile, Vice-Admiral and Chairman; Jas. Bain, John Inglis, Alex. B. W. Kennedy, John List, J. T. Milton, M. E. Browning and Wm. H. Wood, Joint Secretaries.

I concur with the above report, except as regards paragraph 3, and on the point dealt with in that paragraph my report is as follows:

1. Although the Belleville boiler has certain undesirable features, I am satisfied, from considerable personal experience, and from the evidence of engineer officers who have had charge of boilers of this type in commission ships, that it is a good steam generator, which will give satisfactory results when it is kept in good order and worked with the required care and skill.

I am also satisfied, from my inspection of the boilers of the Messageries Maritimes Co.'s S.S. "Laos," after the vessel had been employed on regular mail service between Marseilles and Yokohama for more than three years without having been once laid up for repairs, that with proper precaution, the excessive corrosive decay of the tubes which has occurred in some instances can be effectually guarded against.

2. Having in view the extent to which Belleville boilers have already been adopted for his Majesty's ships, and the fact that there are now three or four other types of water-tube boilers which promise at least equally good results, I am of opinion that, pending the issue of the final report of the committee, Belleville boilers should not be included in future designs. At the same time, I see no necessity for delaying the progress of ships which have been designed for Belleville boilers in order to substitute another type of boiler. Jos. A. Smith.

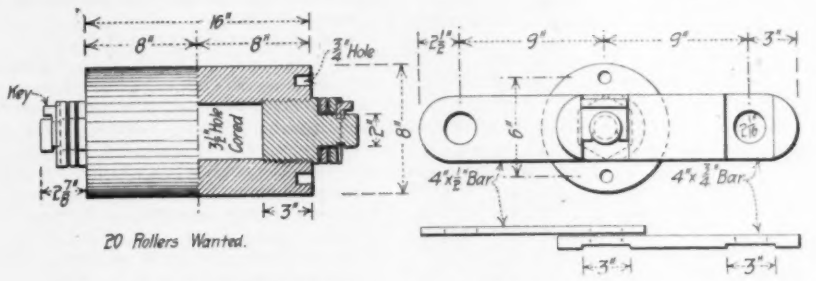


FIG. 8.—DETAILS OF ROLLERS FOR SHIELD FOR EAST BOSTON TUNNEL.

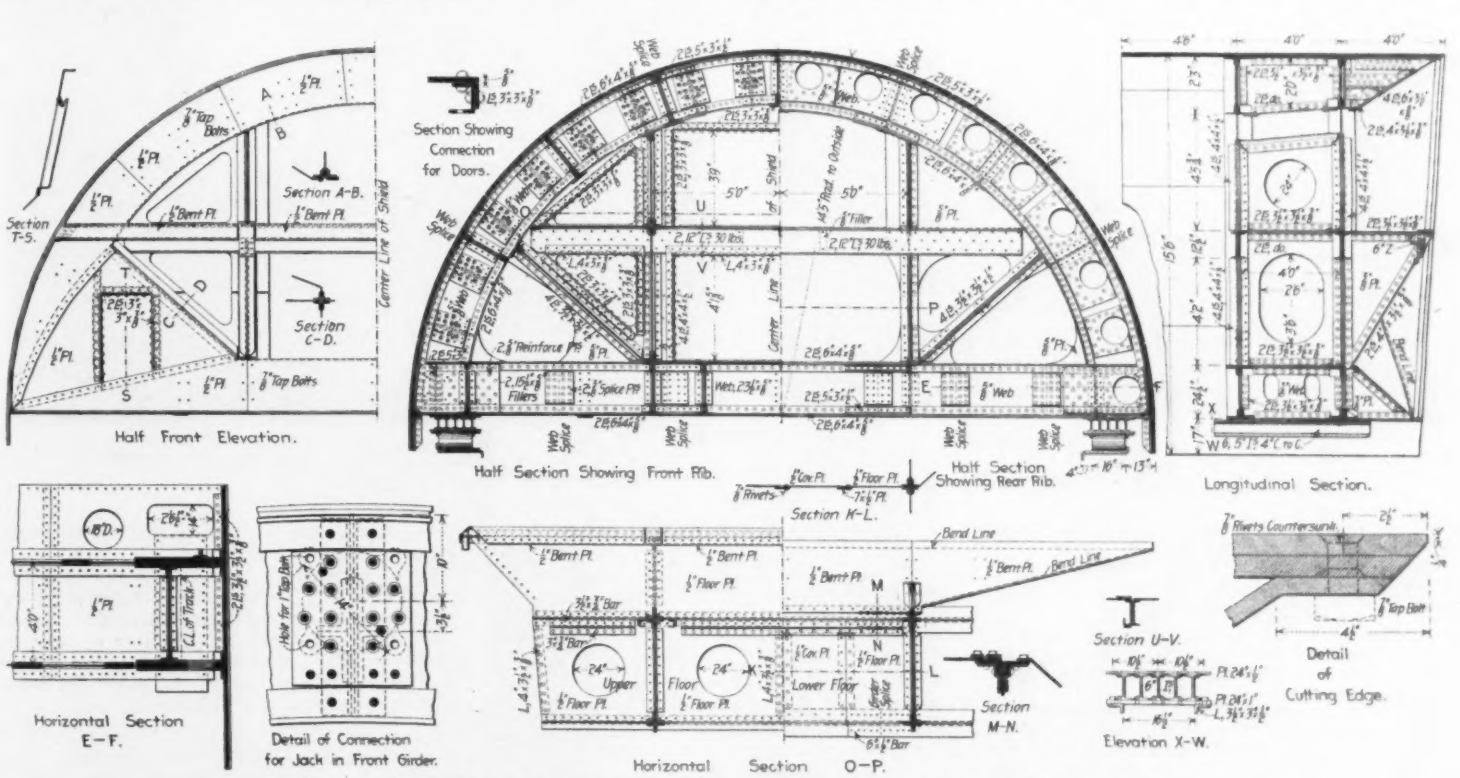


FIG. 9.—DETAILS OF ROOF SHIELD FOR HARBOR SECTION OF EAST BOSTON TUNNEL.

EXPERT COMMISSION'S PLANS FOR INCREASING THE FLOW THROUGH THE CHICAGO DRAINAGE CANAL.

The commission of experts appointed to devise ways for increasing the flow of water through the Chicago Drainage Canal, without injuring the navigability of the Chicago River, has submitted its complete report and submits two plans, which it styles a "radical plan" and a "moderate plan," involving an expenditure of $22,862,879 and $12,701,755, respectively. Briefly described, the radical plan involves the widening and deepening of the Chicago River, from its mouth to the beginning of the canal, near Bridgeport, on the South Branch, with a lowering of the tunnel to 30 ft. below the water lines. The cost of lowering the tunnels is not, however, included in the estimates. The moderate plan is to build a canal from the lake to the river at 16th St., and deepen and widen the river from 17th St. to the canal entrance. Stated in more detail, the two plans comprise the following work, according to the quotations from the report printed in the Chicago daily papers.

The radical plan contemplates a bottom width for the canal, from Robey St. to Summit, of 220 ft., a width of 360 ft. in the Chicago River; from 12th to Robey St., with a depth of 25 ft.; from 12th to Lake St., a width of 300 ft. and a depth of 30 ft., and between Lake St. bridge and the lake a width of 300 ft. and a depth of 26 ft. All center piers are to be removed and docks to be of masonry on pile foundations. It is figured this would give a flow of 989,280 cu. ft. a minute at average lake level, with a velocity from Lake St. to 12th of 1.30 miles an hour, and from 12th St. to Robey of 1.25.

The moderate plan involves the lowering of the tunnels to a depth of 26 ft., a canal from the lake to the river at 16th St., 80 ft. in width and 25 ft. in depth, and a widening and deepening of the river from 17th to Robey St., the same as in the radical plan. For the same flow of water the estimated current from 17th to Robey St., is 1.21 miles an hour.

SUMMARY OF WORK DONE.

As addenda to their report, the experts furnish the following summary, showing their conclusions and the manner in which they have been reached:

The common outlet (the drainage canal proper.—Ed.) has been constructed from a junction with the south branch of the Chicago River at Robey St., to and through the Desplaines Valley, to the controlling works near Lockport, a distance of 28.03 miles. The outlet has been sub-

stantially completed for a distance of 20.27 miles below Summit; the reach in earth from Summit to Willow Springs, 5.40 miles, with a width of 202 ft. in bottom and side slopes of 2 to 1; the reach in rock, 14.87 miles, with a width of 160 ft. on bottom and nearly vertical sides; and a depth of 24 ft., more or less, as the channel may be fed. The reach in earth from Robey St. to Summit, 7.70 miles, has a bottom width of 110 ft., with side slopes of 2 to 1, and is intended for enlargement. All bridges are swing or bascule, to be put in operation in 1907.

The capacity with 24.4 ft. depth at Willow Springs is: Lake at Chicago datum, in feet per minute, 836,280; at mean lake level, 1.6 ft. above datum, 911,160; at high lake level, 3.2 ft. above datum, 989,280.

Collateral work and adjuncts consist of the river diversion, Joliet reach, improvement of Chicago River, the 39th St. conduit, and the Lawrence Ave. conduit. The river diversion needs a small amount of work to complete the same and keep all Desplaines flood waters down the valley. The improvement of Chicago River consists of changes in dock lines and dredging, in which the United States has co-operated, and the building of by-passes and new bridges. The by-passes and the new bridges determine the "moderate improvement" of the river. The 39th St. conduit is building by the city, under certain agreements with the district, for the purpose of circulating the south fork and providing a water supply for the main channel. The Lawrence Ave. conduit is also building by the city, under certain agreements with the district, for the purpose of circulating the north branch.

The cost of canal and other data of the Sanitary District are as follows:

Area in square miles	185
Population, census of 1900	1,627,972
Valuation, equalized for taxation of 1900	$269,287,109
Expenditures to Dec. 31, 1900	35,300,719
Expenditures on adjuncts by city	855,856
Obligations for work done, work under contract, and work required to complete existing projects.	1,546,665

The foregoing includes new contracts let since Jan. 1, but does not include value of claims pending in court,

DETAILED ESTIMATES OF COST.

The detailed figures of the cost of the two plans are:

RADICAL PLAN.

Main channel, Summit to Robey St., 7.65 miles, and controlling works:

Excavation	2,551,822 yards @ 22 cts.	$561,401
Excavation	3,414,620 " @ 28 "	956,094
Additional land for spoil banks 48.2 acres		49,405
Controlling works, completing		50,000
Total		$1,616,900

River, Robey St. to 17th St., 13,990 ft., 2.65 miles.

Real estate	2,197,168 sq. ft.	$2,091,791
Improvements		839,000
Docking	20,278 ft.	506,950
Excavation	3,515,596 yds.	794,936
Bridging, 8; Ashland and Main alterations only		844,800
Special, gas tanks, railway tracks, lumber, etc		158,920
Total		$5,236,397

River, 17th St. to Lake Michigan, 17,823 ft., 3.37 miles.

Real estate	1,749,312 sq. ft.	$8,025,836
Improvements		2,480,630
Docking, 13,905 ft. concrete masonry	$2,174,742	
Docking 10,007 ft. ordinary dock	250,175	
		2,424,917
Excavation	2,605,763 yds.	822,799
Bridging, 18; C.T.T. Ry. & Taylor altrations only		2,232,600
Special, railway tracks		22,800
Total		$16,009,582

Summary.

Completing main channel	$1,616,900
River, Robey St. to 17th St.	5,236,397
River, 17th St. to Lake Michigan	16,009,582
Total	$22,862,879

MODERATE PLAN.

17th St. to Lake Michigan, 3.37 miles.

Real estate	124,054 sq. ft.	$552,896
Improvements		104,000
Docking	4,473 ft.	111,825
Excavation	1,132,812 yds.	278,623
Special, railway tracks		2,000
Total		$1,049,344

The Canal, Lake to River, 0.75 mile.

Real estate and improvements		$1,891,239
Construction	3,900 ft. at $365.05	1,423,695
Basin	3,900 ft. crib piers at $72	280,800
Basin, dredging	96,000 yds.	14,400
Bridging		838,980
Special, piling under walls, etc		250,000
Controlling works		100,000
Total		$4,799,114

Summary.

Completing main channel	$1,616,900
River, Robey St. to 17th St.	5,236,397
River, 17th St. to Lake Michigan	1,049,344
The inlet	4,799,114
Total	$12,701,755

The cost of tunnel lowering is not estimated.

capitalization for swing bridges, outstanding agreements with the City of Chicago and administration for 1901. The statement is intended to fill the gap between expenditures made and the estimate of this commission.

PROPOSED NEW WORK.

The general project is intended to develop the full capacity of the main channel without injury to Chicago harbor, all water to be furnished through the Chicago River and certain adjuncts.

The radical improvement of the river throughout provides for a width of 360 ft. and a depth of 26 ft. from Robey St. to 12th St.; 300 ft. wide by 30 ft. depth, with masonry docks, from 12th to Lake St., and 300 ft. × 26 ft. from Lake St. to Lake Michigan.

The moderate improvement and inlet provides for a moderate improvement from 17th St. to the lake and an inlet adjacent to 16th St. on the south; otherwise the same as for radical improvement. The estimate is: 39th St. conduit, operated by gravity, will change the south fork once in 16.7 hours, or 13.3 hours for the inlet treatment, and the estimated cost to complete is $794,310; the Lawrence Ave. conduit is to be completed as a sewer outfall, and the circulation of the north branch is provided through the north shore canal; the local service is fully provided for, so that all sewage, by means of intercepting sewers and the 39th St. conduit and the Lawrence Ave. conduit, and by the circulation of the south fork and north branch, shall reach the Chicago River and the main channel. The adoption of the northern Calumet Canal route would change the solution for the southern part of the district.

FIG. 1.—WRECKAGE AT 24TH ST. AND AVE. I., LOOKING WEST.

FIG. 2.—BEAM PROJECTED THROUGH WALL OF HOUSE.

VIEWS SHOWING EFFECT OF TORNADO AT BIRMINGHAM, ALA., ON MARCH 25, 1901.

THE BIRMINGHAM TORNADO OF MARCH 25, 1901.

By Julian Kendrick.*

The morning of March 25 was very cloudy, warm and sultry, with every indication of an approaching thunder storm. At 10 a. m. it suddenly became so dark that artificial lights were required for reading. About this time a funnel-shaped cloud was seen approaching rapidly from the West, accompanied by a heavy rainfall, lightning and thunder.

*City Engineer, Birmingham, Ala.

A reliable witness, located at an excellent point of observation, about 4,000 ft. north of the path of the tornado, states that "the cloud appeared to be about 12 ins. in diameter at the lower extremity and about one acre in area at its upper end, traveling very rapidly, ascending and descending as it moved; that whenever the lower extremity touched a building a mass of wreckage would be sucked up and whirled through the air." Others describe the cloud as "bounding along as if composed of rubber."

The effects of this vertical motion are very apparent along the track of the tornado, where uninjured houses, singly and in groups of two or three, located directly in the path, were left standing. In one instance, eight out of a row of two houses were totally destroyed. The two left standing were the weakest in the lot, yet they escaped with the loss of only a few bricks from the chimney tops. After passing over a row of houses, located at right angles to and across its path, the tornado descended again and totally demolished every building in its path for several blocks. In many instances the walls were forced outwards, the roof settling down upon the floors.

Large trees, 1 and 2 ft. in diameter, were either wrenched out by the roots or twisted off near the ground, and fell in all directions across each other. The track of the tornado was almost due east and west, entering the Birmingham valley (which extends northeast and southwest) about ten miles west of the city and leaving about five miles east of it.

The track of the tornado was at some points not over 50 ft. wide, and nowhere in the city over 400 ft. in width. It had a zigzag course, but at no point in the city did it vary over 200 ft. from a straight line.

It is very noticeable that on each side of its path the current of air was towards the path. Large trees are to be seen outside of the path on opposite sides, lying with their tops pointing towards and almost at right angles to the track of the tornado, and small buildings on each side have been moved a short distance or lean towards the path.

A good idea of the carrying capacity of the wind is given by Fig. 2, where a built-up beam, some 8 × 10 ins., × 30 ft. long, is seen to have pierced the front of a cottage. The cottage sustained no other injury. That the beam was traveling towards the path of the tornado (which is to the right of the cottage) is shown by the direction in which the tree has been bent by the beam. The front of the cottage is almost at right angles to the path of the tornado. There is no building within 400 ft. of the cottage from which the beam could have come, and it is believed that it traveled a much greater distance.

Two blocks east of this cottage, and 700 ft. north of the extreme northern edge of the tornado's path, the roof of a one-story cottage was completely crushed in by a portion of a foot-bridge

which fell upon it; one piece 6 × 8 ins. × 18 ft., and several 3 × 10-in. plank.

There were eight or ten houses in the group, and with the exception stated, none received the slightest damage. The occupants of the injured house and of the neighboring ones unite in saying there was practically no wind blowing in that locality when the timbers fell.

Between 200 and 300 houses were totally destroyed, and many others were more or less damaged, principally one-story frame cottages. Fourteen lives were lost, and about 100 persons were more or less injured. The small number of fatalities can only be accounted for by the bursting of the houses, as in many cases the houses were totally demolished, but the furniture was practically uninjured.

It would be practically impossible to select another route through the city where the property loss would have been so light.

Barometer readings and wind velocities are not taken at the weather bureau station here. There was no wind storm except in the immediate vicinity of the tornado.

THE WATER SUPPLY OF PARIS.

On June 11, 1900, the reservoir of Montsouris, in Paris, for the first time received water from the new source of potable water, at Loing and Lunain, and the general supply of the City of Paris was augmented to the amount of 50,000 cu. m. per day. The following abstract of a paper upon the water supply of the French Capital is taken from "Le Genie Civil," of Jan. 19, 1901, and it contains much matter of interest on this head.

Including the amount noted above, the City of Paris is now supplied with 290,000 cu. m. of potable water per day; or about 76,600,000 U. S. gallons. To this must be added a daily supply of 60,000 cu. m., or nearly 18,000,000 U. S. gallons, of filtered water from the River Seine, making a total supply of 94,470,000 U. S. gallons daily. This supply, however, diminishes during the dry season to a total of 280,000 cu. m., or 74,000,000 U. S. gallons daily, providing about 29 U. S. gallons per head per day.

For various industries, for washing the public streets, flushing sewers, etc., 520,000 cu. m., or about 127,400,000 U. S. gallons of impure water are also consumed daily; and this water comes either directly from the rivers Marne and Seine, or from the Canal Ourcq, or from artesian wells. Adding this volume to the above, we have a daily water consumption in Paris, for all purposes, of 800,000 cu. m., or 211,360,000 U. S. gallons. The present population of Paris touches 3,500,000; but as nearly 5,000 acres of land inside of the fortifications of Paris are not yet built upon, there is evidently plenty of room for a further growth in population. In 1789, the people of Paris were content with a supply of water amounting to an average of 3.4 U. S. gallons per head per day, or 8,000 cu. m. for the city. In 1854, the total supply was raised to 80,400 cu. m., and it touched 370,000 cu. m. in 1878; since 1878 the total consumption has more than doubled in volume.

The present supply of potable water, or water from the source, as the Frenchmen call it, comes from the following different gathering points:

From the Dhuis	20,000	cu. m.
" " Vanne	120,000	"
" " Avre	100,000	"
" " Loing and Lunain	50,000	"
Grand Total	290,000	"

In 1855, the municipal council approved of a project for bringing to Paris water obtained from an uncontaminated source of supply; and the project included water gathered in the valleys of the Somme-Soude, the Dhuis and the Vanne. The first-named source was abandoned and the engineer Belgrand fixed up the Dhuis, as having alone withstood the exceptionally dry year of 1857. Water from this source was first distributed in Paris on Oct. 1, 1865; coming through an aqueduct 81.2 miles long, which emptied into the reservoir of Menilmontant. The cost of the supply was 18,000,000 francs, or $3,600,000; and the pure water thus brought to Paris was distributed in the higher quarters of the city, on the "Right Bank" of the Seine.

In 1865, the supply from the Vanne was taken up, and an aqueduct was finally built which was

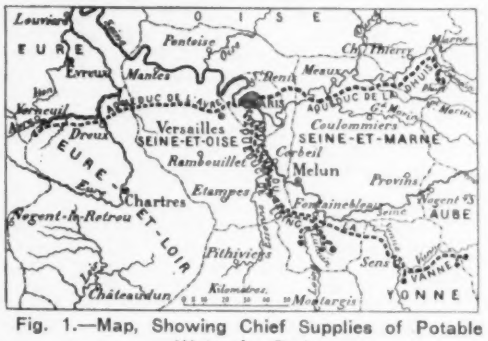


Fig. 1.—Map, Showing Chief Supplies of Potable Water for Paris.

107.3 miles long; of this 97.3 miles constituted the principal artery. Of this total length, 21,500 m. were siphons, and 151,500 m. were masonry conduits. This aqueduct emptied into the reservoir of Montsouris, in Paris, which now includes two sets of superimposed basins with a total storage capacity of 204,000 cu. m. of water. The work was actually commenced in 1867, but was interrupted by the war of 1870-71, and was finished in 1874.

The water from the Avre is brought to Paris by an aqueduct 73.24 miles long. Work upon it was commenced March 31, 1893, and it is not yet completed in all its details, owing to legal disputes with the landowners. In 1900, it had already cost 36,000,000 francs, or $7,200,000.

The last supply secured—that from Loing and Lunain, and which partly parallels the Vanne aqueduct, was authorized on Nov. 28, 1892; and the cost was included in the general law of July 10, 1894, authorizing the City of Paris to expend 117,500,000 francs, for the improved sanitation of the city; in this law 50,000,000 francs was set aside for an additional water supply for Paris. The water is gathered from seven separate sources, lying about 46.5 miles from Paris, in the Department of Seine-et-Marne, the water being of an excellent quality.

The work of constructing this last aqueduct was divided into three separate operations: The impounding of the water and the building of the secondary aqueducts; the erection of a pumping station for lifting the water to the main aqueduct level, and the construction of the main aqueduct. This main aqueduct has its origin in the Forest of Fontainebleau, and is 45.5 miles long, to the fortifications of Paris. It is made up chiefly of a masonry conduit running partly full, having a gravity fall of 0.33-ft. in 3,281 ft. The valleys are crossed by means of siphons, made either of cast iron or of steel plates, and laid in one or in two series of pipes. Wherever possible the conduit was constructed in a trench, as shown in Figs. 2 and 3; it was built of a ring of masonry, with an interior diameter of 8.23 ft., and the interior face of the circle was coated with about ¾-in. of an especially hard mortar up to the normal water level.

The exterior profile of the masonry was determined as follows: In a trench, the exterior line of the lower half of the conduit was a circle, concentric with the inner circle, and of such diameter as to allow a uniform thickness of 9 7-16-in. in the lower portion of the aqueduct. Above the horizontal diameter, on each side, the thickness is increased to the level of the water carried in the aqueduct, by an outward batter of 0.05-m. per meter, commencing this slope at horizontal diameter; from the apex of the angle thus made, a tangential line to the exterior surface completes the profile. A coating of the same hard mortar is carried up to the normal water level. In tunnel work, or when the trench was very deep, the thickness of the conduit was uniform all around, with no angles.

When the conduit came partly above the surface—as in Fig. 4, the exterior profile was made of a half-circle surmounting a rectangle; and the thickness of the walls was 0.24 m. at the crown, and it varied as follows in the other parts: When the normal water level is between the natural level of the earth and 1 meter above that level, the bottom thickness is 0.25-m.; this latter thickness is 0.45-m., when the water level is between 1 m. and 1.85 m. above the natural earth; and is 0.60-m. when the water plane is more than 1.85 m. above the earth. In rock, these thicknesses are reduced; but it is never less than 0.25-m. When the elevation of the normal water level in the conduit exceeded 1.85 m., or about 6 ft., and where the nature of the ground made it possible, the conduit was founded upon arches, or parts of arches, having a radius of 16 to 20 ft.

As a rule, the siphons were laid with two lines of pipes, proportioned to carry the total capacity of the aqueduct, which is 180,000 cu. m., or 57,556,000 U. S. gallons, in 24 hours. But, as provision is made in these siphons for a future supply of water to the upper part of the Seine basin, the principal siphons really have a duty of 120,000 cu. m. for each line of pipe. These main siphons are divided as follows: The Bievre, made of riveted steel pipe, has a fall of 0.33-ft. in 3,281 ft., and is 5.50 ft. diameter; the siphons of Orge and Essonne, are made of cast iron, and have a fall of 0.82-ft. in 3,281 ft., and are 4.92 ft. in diameter; the other siphons are all cast iron, have a fall of 2.69 ft. in 3,281 ft., and a diameter of 4.10 ft. The steel pipe siphon is located in a masonry gallery with sufficient space about it to admit of inspection and repair. There are six of these siphons in all, varying in length from 2,058 m., or 6,750 ft., to 290 m., or 951 ft.

The pumping plant is located near the edge of the Forest of Fontainebleau, on the railway. There are four groups of pumps, each operated by horizontal, single-cylinder engine of the Corliss type, with Girard plunger pumps. Three of these pumps have a capacity sufficient to raise to the aqueduct level the total flow of this aqueduct, while the fourth group is in reserve.

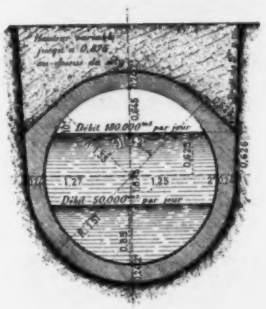


Fig. 2.—Section of Main Aqueduct, in Trench.

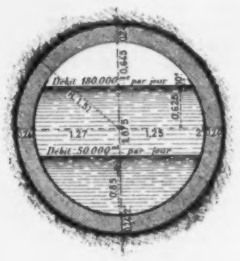


Fig. 3.—Section of Main Aqueduct, in Tunnel.

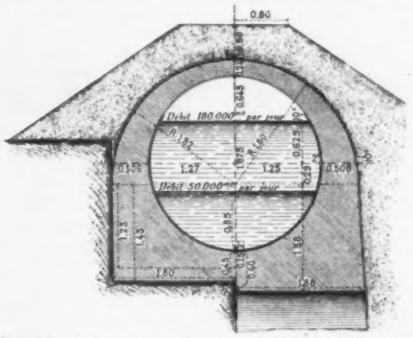


Fig. 4.—Section of Main Aqueduct, Partly Above Ground.

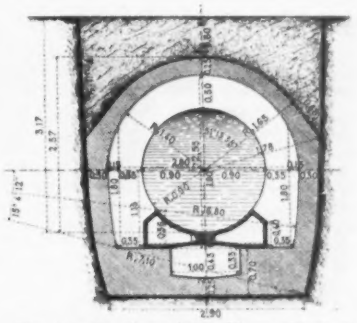


Fig. 5.—Section of the Bievre Riveted Steel Siphon in a Masonry Gallery.

This work was commenced in 1898 under the direction of M. Humblot, Inspector General, and M. F. Bienvenue, Engineer in Chief. The total cost, according to the original estimate, was $3,690,000, as follows:

		Francs.
Total earthwork and masonry		10,939,000
Cast-iron siphons		3,846,000
Rivetted-steel siphons		1,095,000
Drainage and making foundations in bad ground, etc.		2,020,000
Engineering	450,000 f.	17,900,000
Expense attending the acquiring of land	100,000 f.	550,000
Grand Total		18,450,000 f.

A MODERN AMERICAN BLAST FURNACE; ITS CONSTRUCTION AND EQUIPMENT.*

By Arthur C. Johnston, M. E.†

(With eight-page supplement of illustrations.)

In an article written in 1896, entitled "Forty Years of Progress in the Pig Iron Industry," John Birkinbine says:

A retrospect of four decades will show that this interval covers most of the advances in the production of pig iron made in the United States, and also those introduced in European countries, for, although the use of mineral fuel, the application of heated blast, and the employment of steam-blowing machinery were not uncommon features of smelting plants, the increased production of pig iron up to 1855 was due chiefly to an augmented number of blast furnaces and enlarged dimensions of stacks. But what was considered at that time a large furnace would now rank as small, while the quantity of metal obtained in a year from the greatest producers of 40 years ago was equaled by the monthly output of a number of modern furnaces in 1895.

The relative proportions of representative furnaces, from 1855 to 1900, are well shown in Fig. 1, plate I.

Much has been written about the increasing size and output of furnaces generally, but, on account of the rapidity of development, very little concerning their actual construction and the means employed for bringing about the increased production. The object of this paper is to describe the mechanical construction of a modern furnace, its equipment and the appliances for concentrating and handling the enormous amount of material that is required to make 600 tons of iron per 24 hours in a single stack; and to draw some conclusions based on the operation of such a furnace, taking as a concrete example the plant of the Lorain Steel Co., at Lorain, O. It is regretted that it will not be possible, within the limits of this paper, to introduce other furnaces for the sake of comparison, but it is hoped that the record of experience in the operation of the Lorain furnaces—two of the largest in the world—will be of value in the design of perhaps still greater iron producers.

The plant mentioned was built in 1899, and consists of two stacks, each 100 ft. high from hearth level to furnace platform, 22 ft. in diameter at the bosh, and 14 ft. at the hearth. By reference to Figs. 2, 3 and 4, plate II., it will be seen that they are arranged on the American system, which places two furnaces in a group, there being four heating stoves for each furnace and a boiler house and engine house common to both. The plant is arranged to be capable of extension by adding to the engine and boiler houses, making them of sufficient capacity for another similar group of two furnaces. Sections showing the lines and construction of the furnaces themselves are shown in Fig. 5, plate II., and Fig. 6, plate III. It will be seen that there is a slight difference between the lines of furnace No. 1 and those of No. 2.

The distinctive feature of these furnaces is the great depth of the hearth jacket, and the low level to which the furnace columns are carried in consequence. The hearth jacket itself is also of novel design. It consists of two series of segmental steel castings, held together by bolts and buckstays, with rust joints at the abutting edges of the different segments. Between the jacket and the masonry there is inclosed a complete ring of individual vertical pipes, intended to serve the double purpose of a cooling system and a means of relieving the jacket of excessive bursting strains, due to the expansion of the contained furnace bottom, by the partial collapse of the pipes. The intention was to have the cooling water for the jacket discharged into the annular space at the top of the same and to carry it downward through the pipes from which it would seek its level within the wall surrounding the jacket, whence it would be led off through a waste pipe placed at the desired level. In accordance with modern practice, the tuyeres are spaced as closely as possible, there being sixteen 6-in. tuyeres in the circle. A special feature is the great number of cooling plates. As will be seen in Fig. 7, plate II., there are 12 rings of bronze coolers, two of which are below the tuyeres and three additional rings of cast-iron coolers above the bronze plates. Fig. 8, plate II., shows clearly the construction of the coolers with their socket plates, and Fig. 9, plate II., the details of the tuyeres. There are, in all, 277 bronze and 48 cast-iron coolers in each furnace. The stock lines are protected by 12 rings of cast-iron segments built into the brickwork. The mantels are built of ⅜-in. steel plate, with two courses of ½-in. plate at the bottom and one at the top. The gases generated in the stacks are led off through two downcomers, each 73 ins. in diameter and brick lined to 63 ins. inside diameter. The general outline of these downcomers may be seen in the general plan of the furnaces, Fig. 4, plate I., and it will be observed that, owing to the steep angle at which they are carried up, it is practically impossible for dust to lodge in them at any point, which is a very important consideration. As a matter of fact, when the furnaces were blown out, after a year's run, these pipes were found to be as clean as a gun barrel. In the dust-catcher, Fig. 10, plate I., the direction of motion of the descending gases is so suddenly changed upward that ample opportunity is given for the precipitation of the dust, which can then be dropped into railway cars standing on the track which runs through the tunnel under the foundations.

The gases are further cleansed by being precipitated against the surface of a body of water in the gas washer, Fig. 11, plate III. From the washer the gases are led into the gas main. A by-pass, however, is arranged whereby the washer can be cut out of the system. This is accomplished by making two connections direct from the dust-catcher to the gas main, controlled by 56-in. cut-off valves, which are fitted with water-cooled seats and discs. The connections from the dust-catcher to the washer, and from the washer to the gas main, are controlled by cut-off valves of a different type, Fig. 12, plate II. In Fig. 13, plate III., are shown the various connections between the downcomer and the gas main.

The gas main is a steel shell 85 ins. in diameter and brick lined to 75 ins., and it extends along the front of the eight stoves, having a downward connection to the burner at each of them. Here again precautions are taken to precipitate the dust carried over by the gas; also in the burner itself there is still another dust-catching chamber. The stove burner is 18 ins. in diameter, with a 6-in. air supply pipe, Fig. 14, plate III., and the opening for it in the stove is 22 ins. in diameter.

Furnace gases are slow in burning, and for economical results a long combustion chamber of ample size must be provided. By reference to the section through the stoves, Fig. 15, plate IV., it will be seen that the combustion chamber is carried up to the top, and that the burnt gases descend through the rectangular passages formed by the stove bricks, which are heated thereby until they reach the desired temperature. Each stove has a heating surface of 34,000 sq. ft. The gases are passed from the stoves to the chimney through a 50-in. valve with air-cooled disc and water-cooled seat; the air is brought down through the stem, as shown in Fig. 16, plate IV. The chimney is 10 ft. in diameter and 225 ft. high, and brick lined to the top, Fig. 17, plate IV.

In designing these furnaces it was figured that each of them would require from 45,000 to 50,000 cu. ft. of air per minute, measured by piston displacement, when making 600 tons of iron each in 24 hours. To supply this volume the engine house is equipped with five horizontal compound blowing engines, with steam cylinders 44 and 84 ins. in diameter, and two air cylinders 84 ins. in diameter, all having a common stroke of 66 ins. The general design of these is shown in Fig. 18, plate III. The fifth engine is intended for a reserve, to be thrown on either pair of furnaces in the contemplated extension. They are designed to be capable of delivering air at a maximum pressure of 30 lbs. per sq. in., although the average blast pressure is only about 14 lbs. Any engine can be connected with either furnace at any time, as the two cold-blast mains run parallel with one another over the blowing cylinders, and each main has a connection with a shut-off valve to each cylinder.

The cold-blast mains are 48 ins. in diameter, and are rolled from ¼-in. plate. Each is equipped with a 48-in. snort valve, which in closing opens a 14½-in. relief valve mounted on the same frame, and thus prevents a dangerous pressure from accumulating in the main when the blast is suddenly shut off from the furnace. In addition, there are three 8-in. safety valves on each pipe. Thirty-inch connections are made from the mains to the stoves, Fig. 19, plate IV., and the valves in these branches have in their seats a smaller valve which opens first automatically and relieves the pressure, an arrangement which enables the main valve to be opened more easily.

The cold air from the blast mains passes into the stoves and up through the checker bricks, which have been previously heated by the burning furnace gases, and down through the combustion chamber—the gas burners having been withdrawn and its door and chimney valve closed—into the hot-blast main through a 32-in. hot-blast valve, Fig. 20, plate V. By referring again to Fig. 19, plate IV., these connections will be readily traced. The hot-blast mains are 69 ins. in diameter, and double brick lined to 50 ins. inside diameter. Before connecting with the bustle pipes, the hot-blast mains divide and join them with two connections in order to better equalize the pressure around the complete circle. From the bustle pipes the hot blast is led to the tuyeres, and into the furnace through the tuyere stocks. Two 16-in. drop valves are placed on the bustle pipe. These open automatically when the blast pressure is shut off, and air is admitted instead of drawing dangerous gases back through the tuyeres from the furnace; these also close automatically when the blast is turned on. Explosion doors are provided at the furnace top, and wherever possible in all pipes and chambers carrying gas.

For handling the stock at these furnaces an entirely new system is in use. The stock bins are placed underground, Fig. 21, plate V. There are five stock bin cars, with suspended weighing hoppers, for the two furnaces. The bins are 725 ft. in length, and the ore, limestone and coke are delivered to the furnace skip car by the weighing cars, which draw their supply from the chutes in the bottom of the bins. The skip then carries the charges up the incline and delivers them at the furnace top, as shown in Fig. 22, plate VIII.

The stock bin cars are driven by two railway motors, and the door in the bottom of the suspended hopper is opened and closed by an air cylinder, the pressure being supplied by an electrically-driven air-pump carried on the car. The operator can weigh all charges from the car platform. The skip has a capacity of 240 cu. ft., and is hoisted, by means of four 1¼-in. cables, by a pair of 14 x 16-in. engines geared 6.5 to 1 to a 72-in. drum. To complete a single "charge" the skip makes four trips—taking first two loads of coke and then two loads of ore and limestone mixed. Two loads of coke, or of limestone and ore, are kept always on the bell in order to act as a seal and to keep it cool. When making 600 tons of iron in 24 hours the skip delivers 90 "charges," making 360 trips to the furnace top, an average of a return trip every four minutes. The skip is counterweighed, so that the engine does work both in raising and in lowering it.

For pumping water for the cooling plates there are two compound, flywheel Holly pumps, each having two double-acting water plungers 22 ins. in diameter, with a stroke of 28 ins. These are capable of delivering 7,000,000 U. S. gallons of water per 24 hours each. As a reserve there is also a duplex pump with two double-acting water plungers, 14 ins. in diameter and 10-in. stroke. All these pumps deliver water to a stand pipe 12 ft. in diameter and 150 ft. high. The water passes through from three to four cooling plates before being discharged into the waste troughs. Arrangement is made also whereby water from the boiler-feed system can be sent through the cooling plates, in order to force out deposits of sediment by means of the increased pressure. Brass ball-and-socket unions are used throughout the piping for the cooling system.

The boiler house is equipped with 24 vertical water-tube boilers, each of 250 HP.; so arranged as to use either furnace gas or coal as fuel. A cross-section of the boiler house is shown in Fig. 23, plate V., as is also the type of boilers used. These boilers are admirably adapted for furnace gas or as fuel, as, on account of their great height, there is sufficient time to effect the complete combustion of the slow-burning gases. The gas main from the furnaces is extended into the boiler house, and has a connection to the burner in front of each grate.

With the increasing output from single furnaces, it was soon found to be practically impossible to handle the pig iron quickly enough when cast in sand beds in the ordinary manner; and this was the first cause of the development of the pig-casting machine, which, with the mixer or storage tank, is one of the most important of recent inventions in connection with the blast furnace. Fig. 24, plate VI., gives a general idea of the form of the machine. It consists of two endless chains carrying molds or chills of pressed steel, the details of which are shown in Fig. 25, plate VI. In operation the machine is beautifully simple. The molten iron is poured from the ladle into a trough terminating in two spouts from which it runs into the chills. The chain then drops down under the surface of the water contained in the tank, and travels under water for a distance of about 100 ft. It then turn upward, and as it ascends the incline the pigs are sprayed with cold water from a spray pipe; and by the time they reach the head of the machine they are sufficiently cooled to be loaded on cars which stand on the loading track. They may, as an alternative, be delivered by the machine to a conveyor, which in turn delivers them to the stock piles for use in the cupolas. The chains travel at the rate of 20 ft. per minute, and the chills are spaced 12 ins. c. to c., so that each chain delivers 20 pigs per minute, weighing on the average 110 lbs. each; and thus it will be understood how very efficient this machine is and what a great saving of labor it represents. Instead of clay-washing the molds to prevent the iron from fusing with them, they

*Note.—Owing to the keen competition of commercial interests in the iron and steel industry in this country, great care has been taken to eliminate from this paper anything that would seriously affect the interests of the company owning the furnaces herein described. It is on this account that the paper is confined to a description—from the standpoint of a blast-furnace engineer—of the mechanical construction of a complete modern furnace plant, the object being to show thereby the great advances that have been made in blast furnace construction and equipment during the last ten years, and to give an adequate idea of the enormous possibilities of the American iron and steel industry, which has at its command such producers as these. The subjects of ore and coke supply, the burdening and grades of ore used, the fuel consumption and the extent and cost of output have been carefully avoided, otherwise the paper could have been made much more interesting and valuable.

*A paper read before the Civil Engineers' Club of Cleveland, Nov. 27, 1900, and published in the Journal of the Association of Engineering Societies for January, 1901.

†Late Mechanical Engineer, Lorain Steel Co., P. O. Box 207, Bristol, Pa.

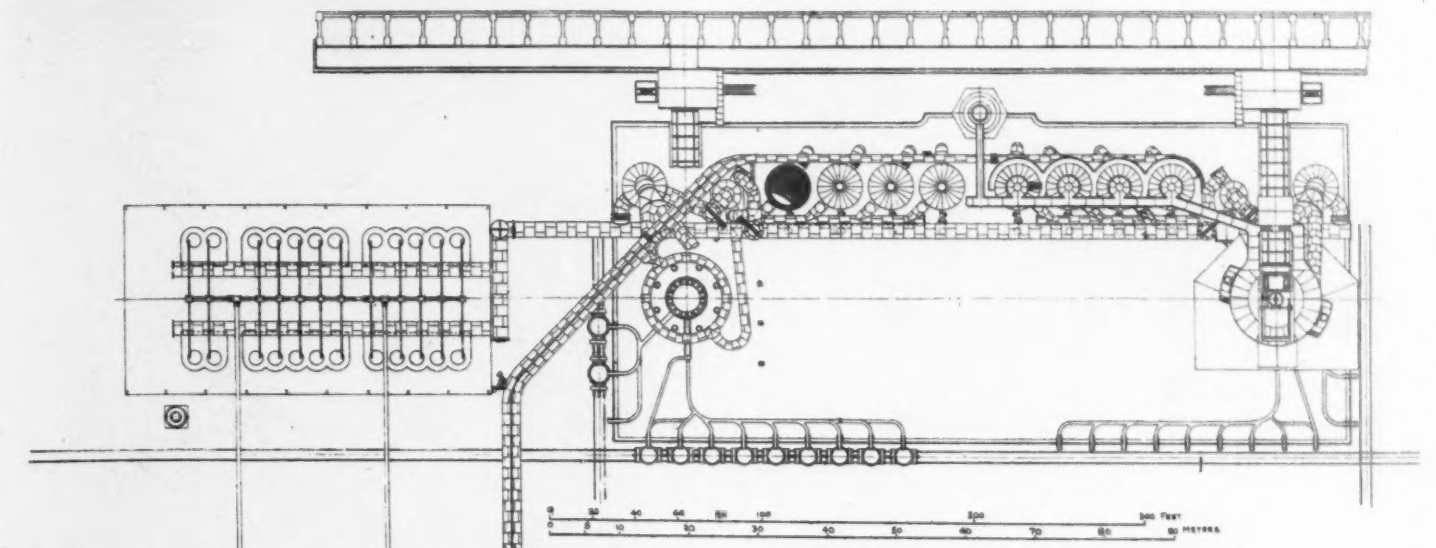


FIG. 2. GENERAL PLAN OF FURNACES.

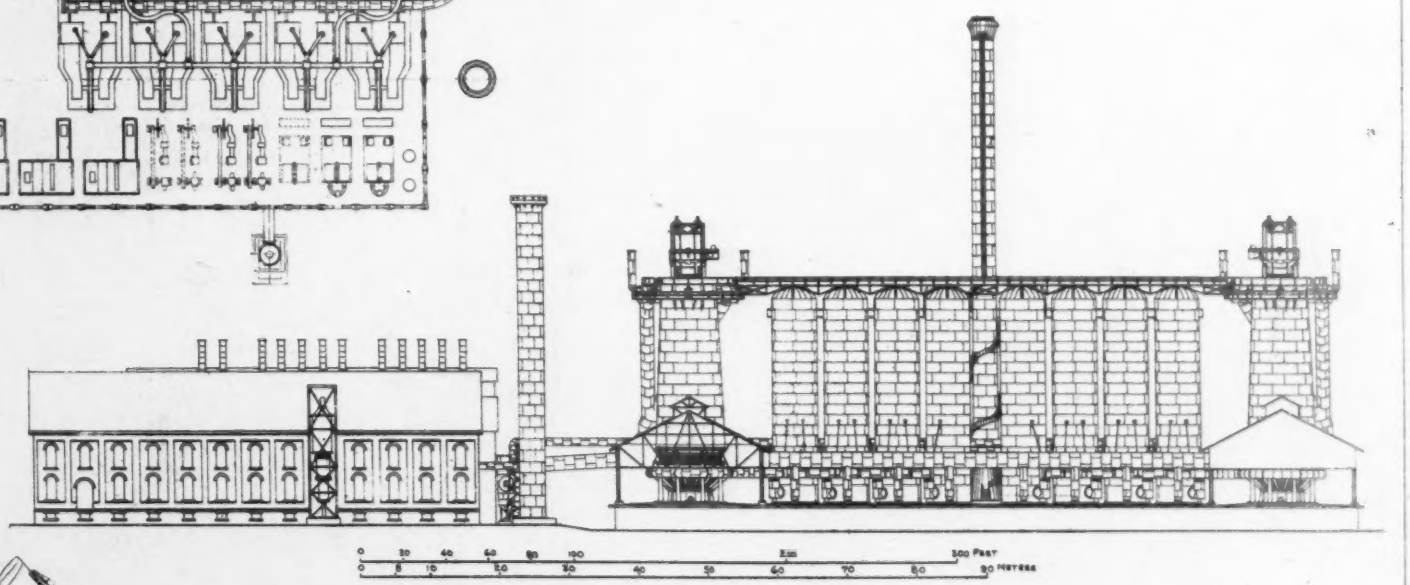


FIG. 3. FRONT ELEVATION OF FURNACES.

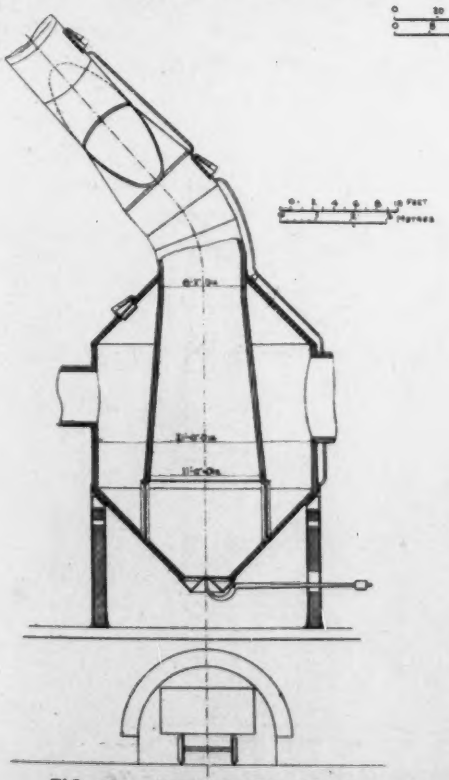


FIG. 10. DUST CATCHER.

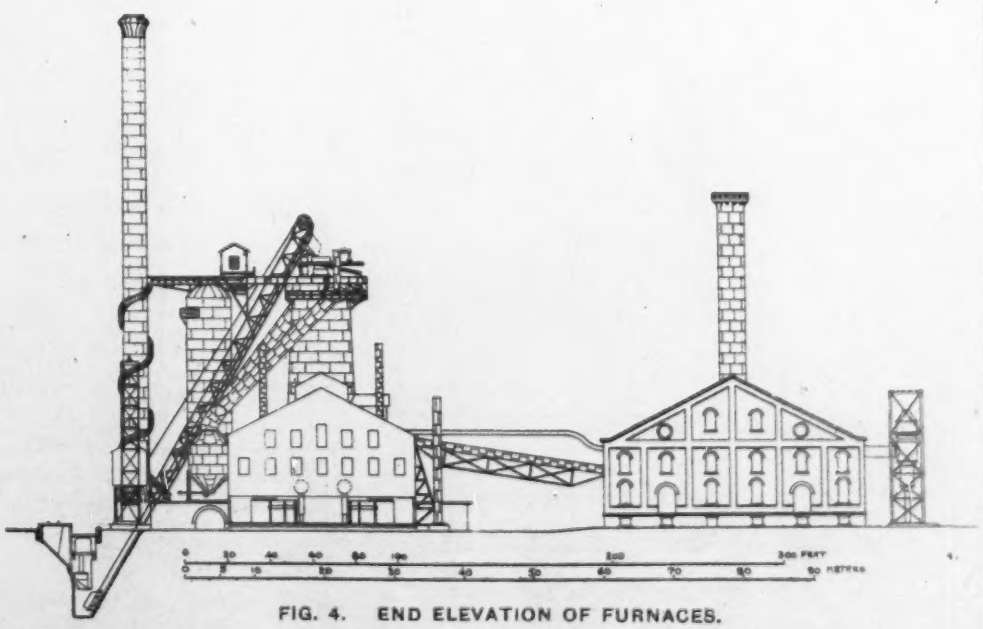


FIG. 4. END ELEVATION OF FURNACES.

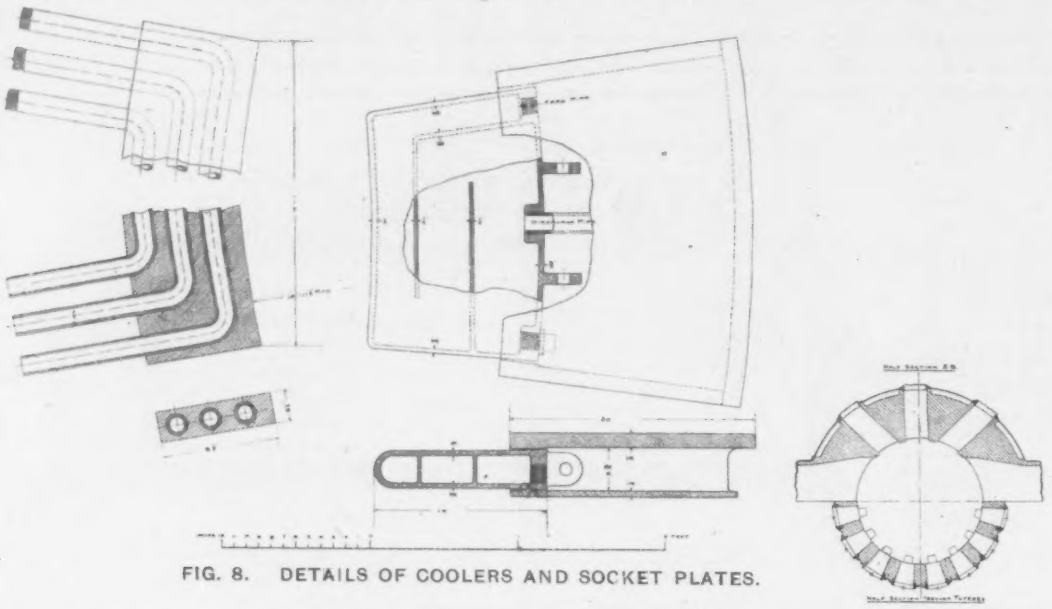


FIG. 8. DETAILS OF COOLERS AND SOCKET PLATES.

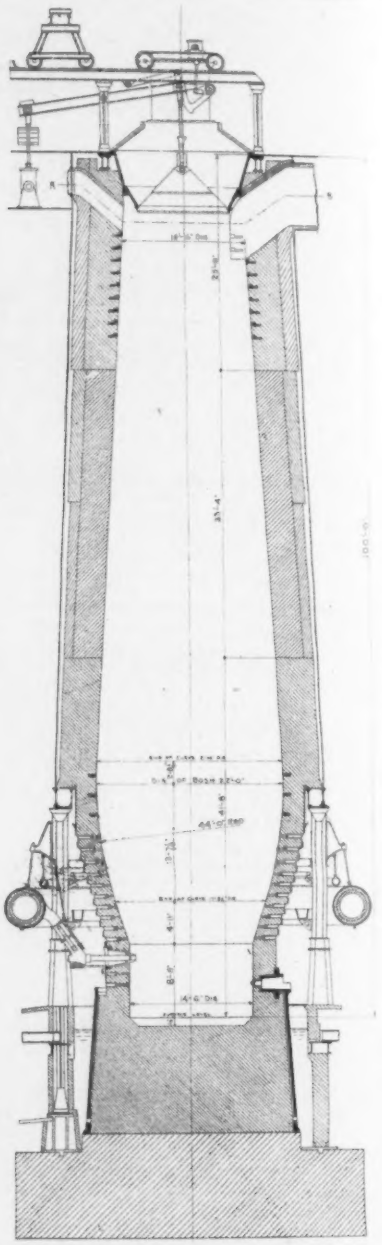


FIG. 5. FURNACE No. 1.

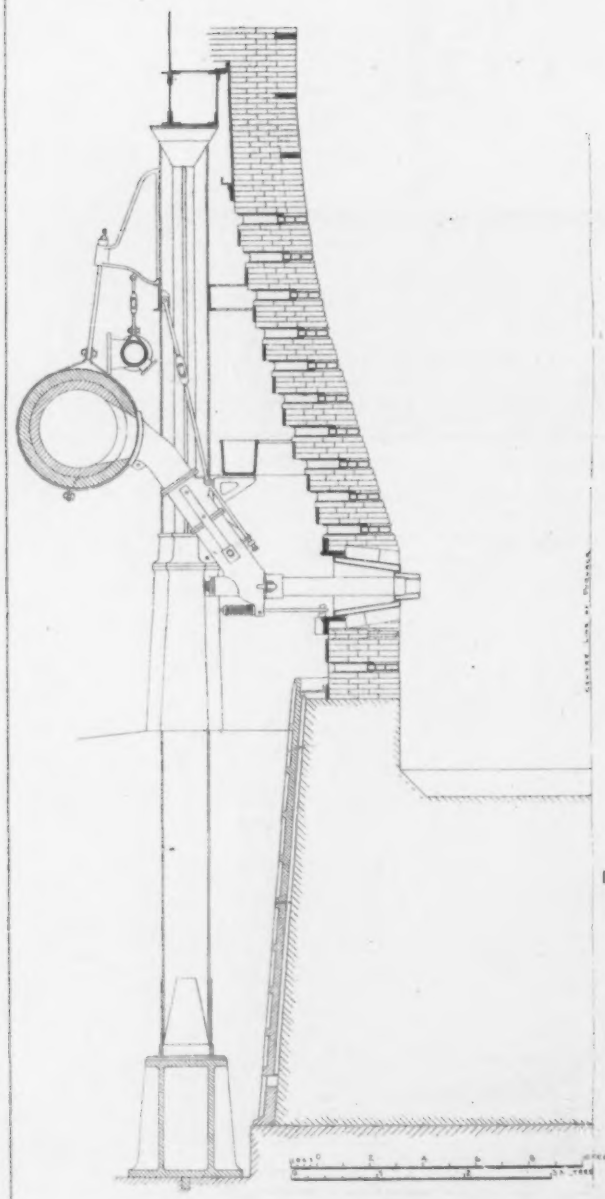


FIG. 7. SECTION THROUGH BOSH WALL.

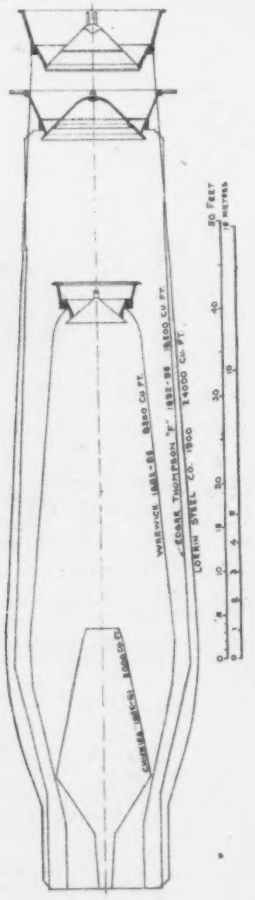


FIG. 1. COMPARATIVE PROPORTIONS OF REPRESENTATIVE FURNACES 1855-1900.

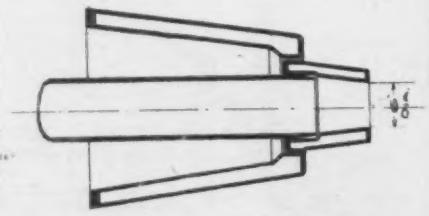


FIG. 9. DETAIL OF TUYERES.

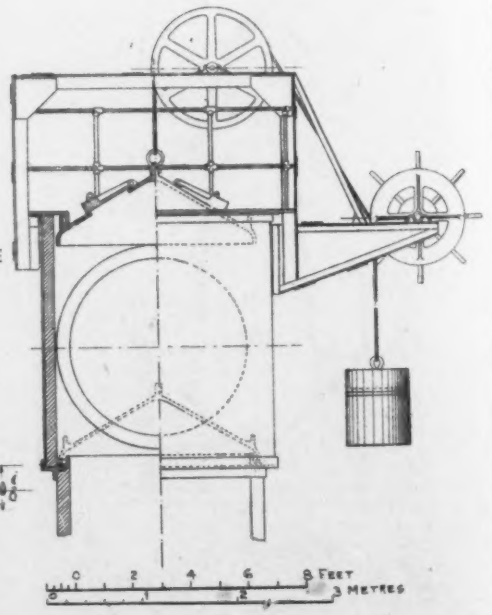


FIG. 12. 75" GAS CUT-OFF VALVE.

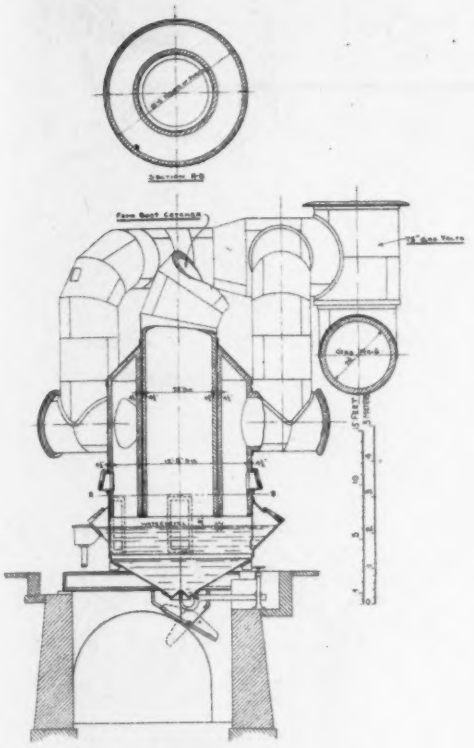


FIG. 11. GAS WASHER.

FIG. 6. LINES OF FURNACE. No. 2.

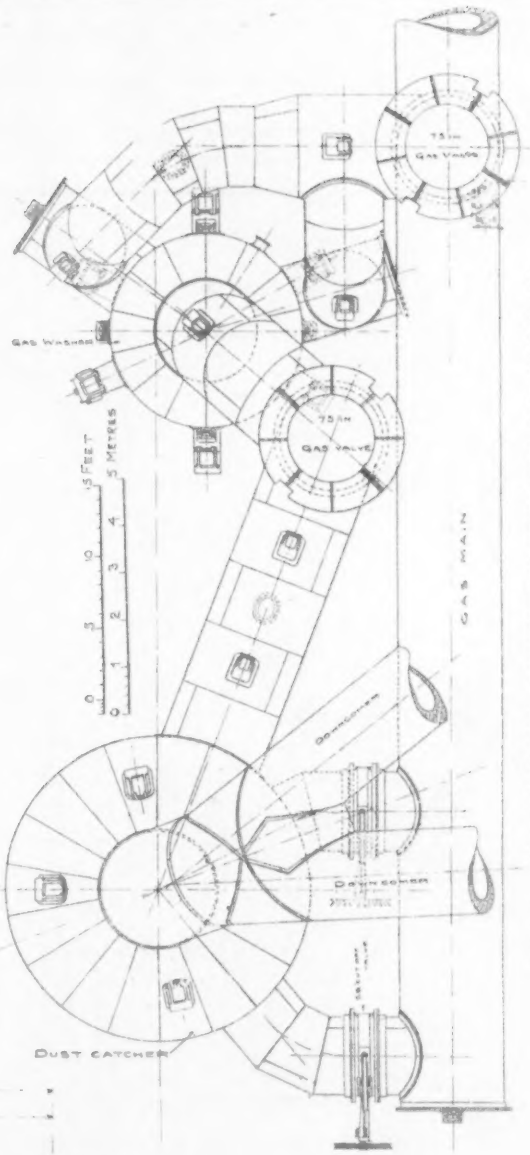


FIG. 13. CONNECTIONS BETWEEN DOWNCOMER AND GAS MAIN.

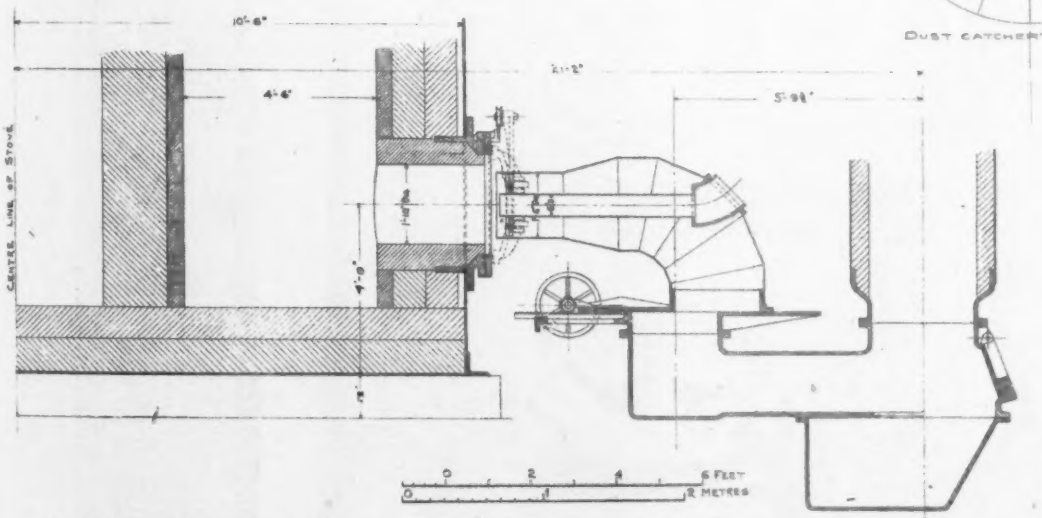


FIG. 14. STOVE GAS BURNER.

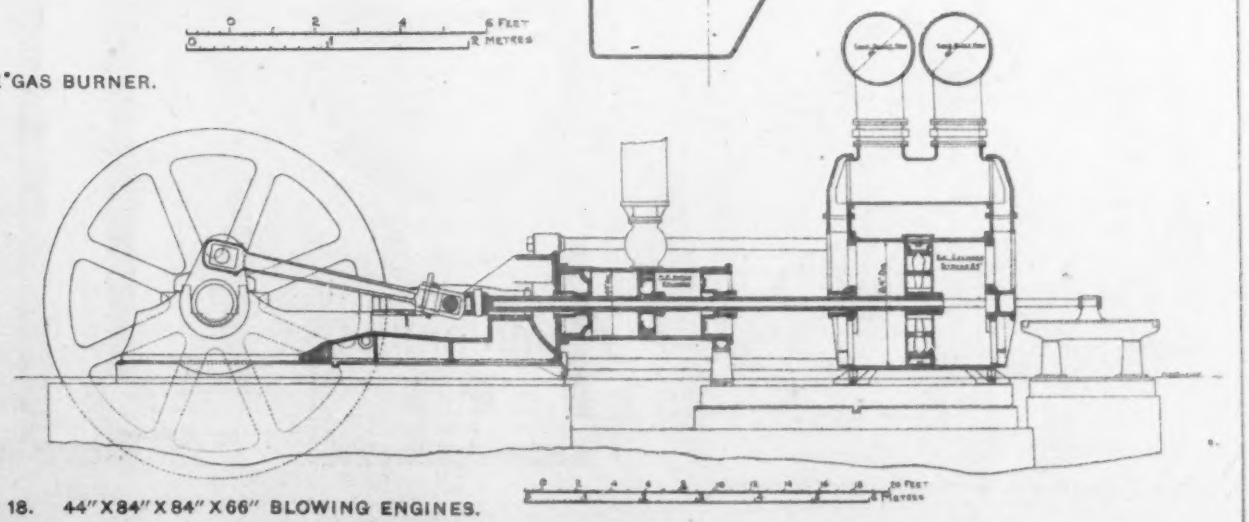


FIG. 18. 44"X84"X84"X66" BLOWING ENGINES.

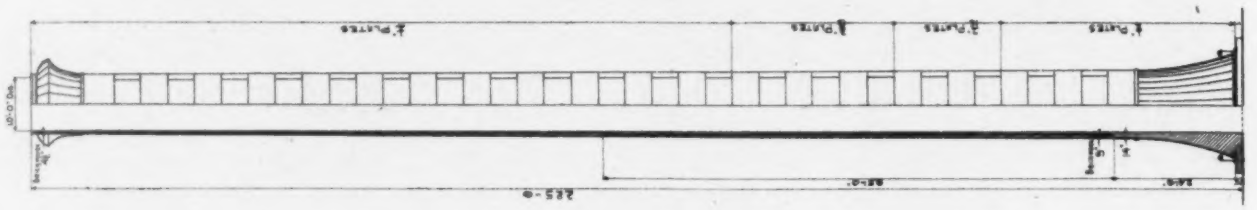


FIG. 17. 10' X 225' STOVE CHIMNEY.

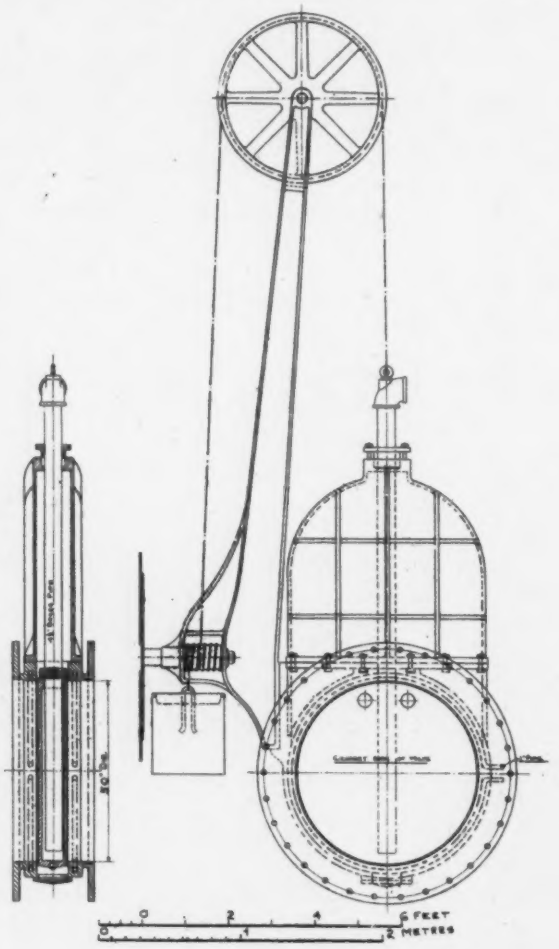


FIG. 16. 50" CHIMNEY VALVE

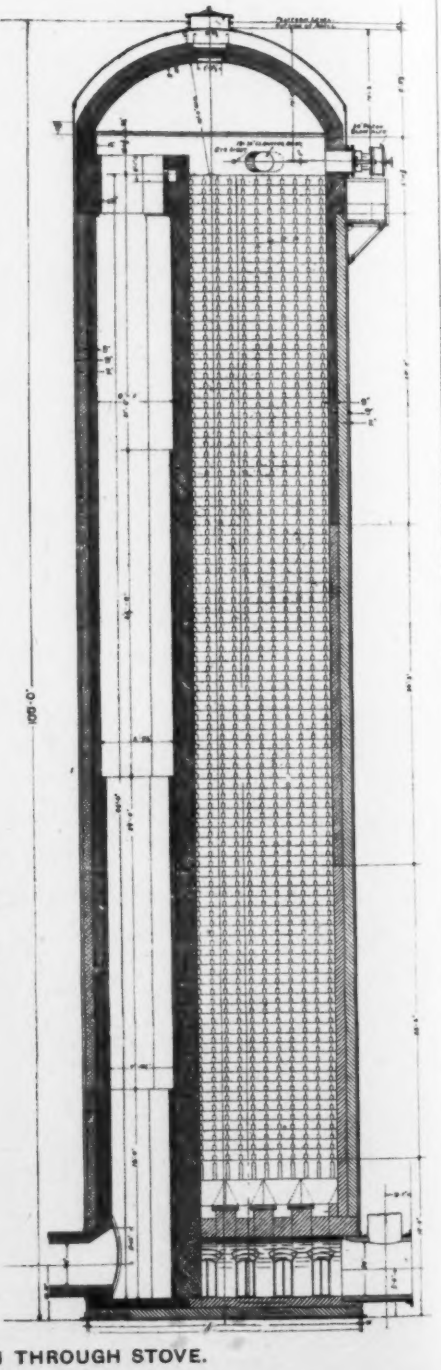


FIG. 15. SECTION THROUGH STOVE.

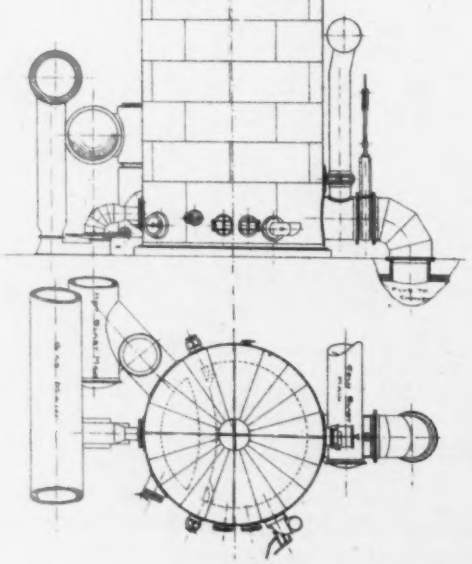


FIG. 19.

STOVE COMPLETE WITH ALL CONNECTIONS.

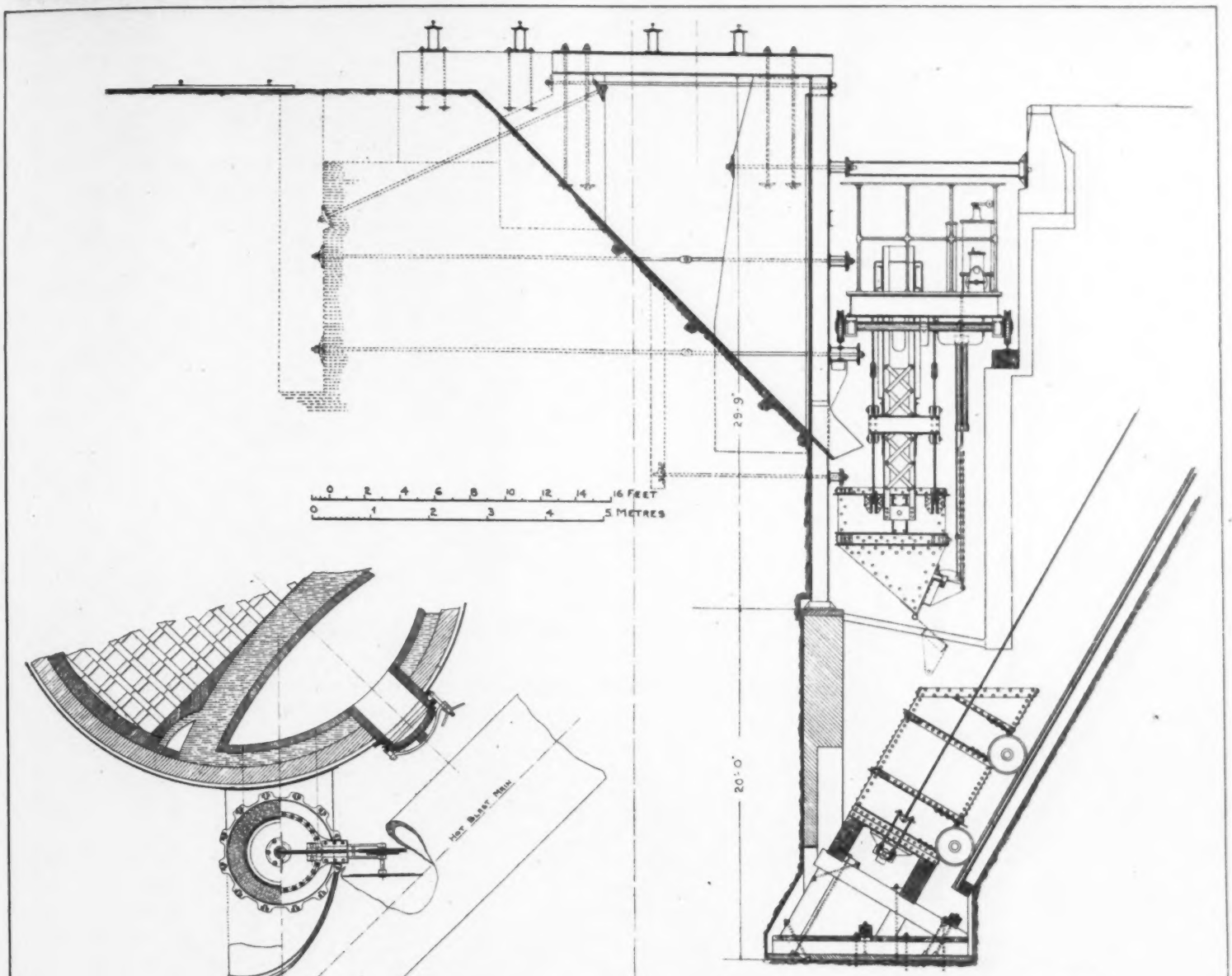


FIG. 21. SECTION THROUGH STOCK BINS.

FIG. 20. 32" HOT-BLAST VALVE.

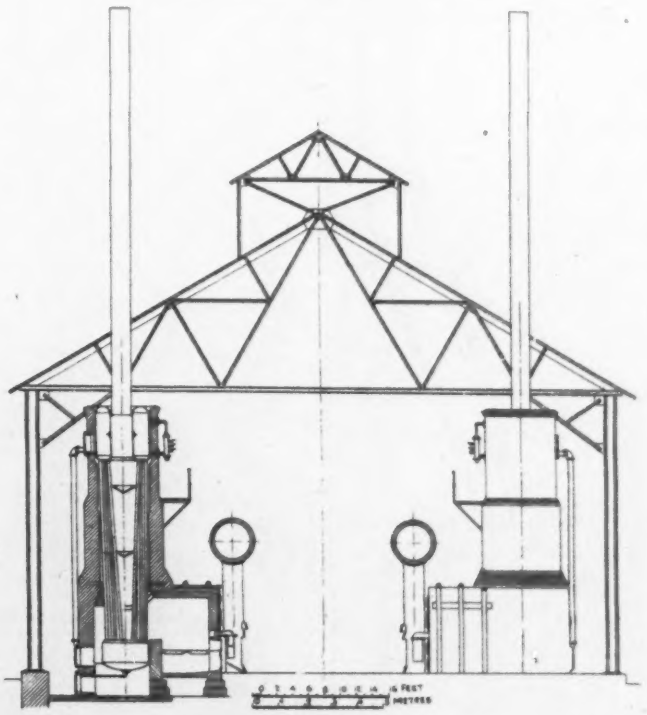


FIG. 23. SECTION THROUGH BOILER HOUSE.

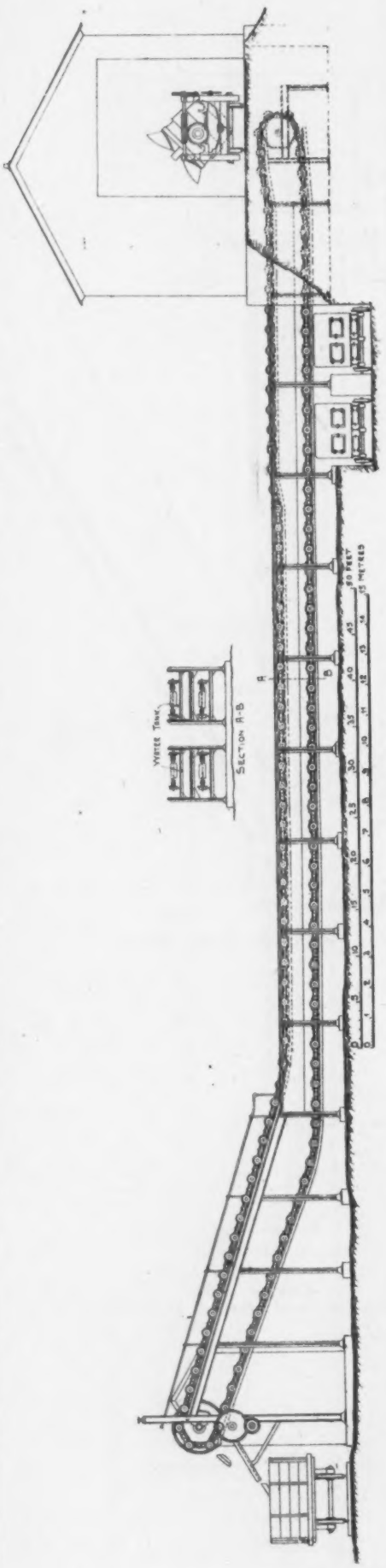


FIG. 24. PIG-CASTING MACHINE.

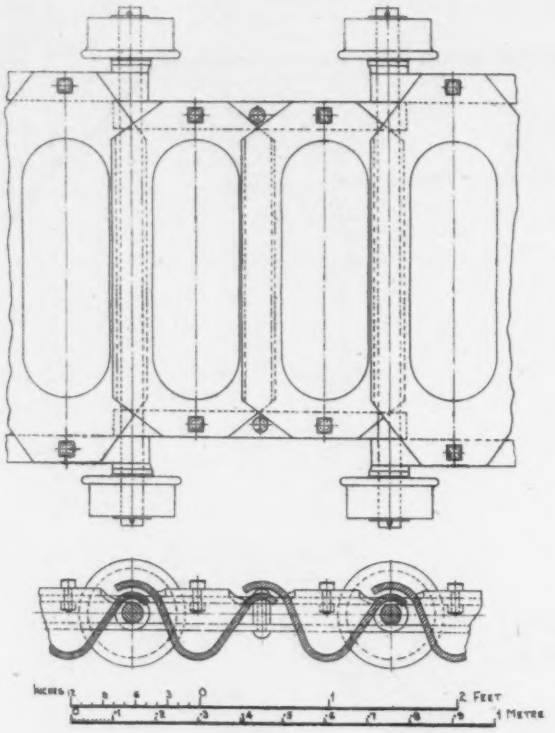


FIG. 25. CHILLS AND CHAINS FOR PIG-CASTING MACHINE.

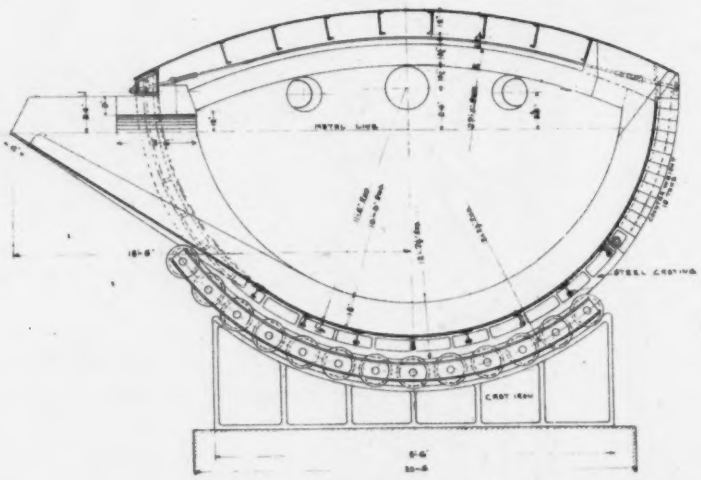


FIG. 29. 300-TON HOT-METAL MIXER.

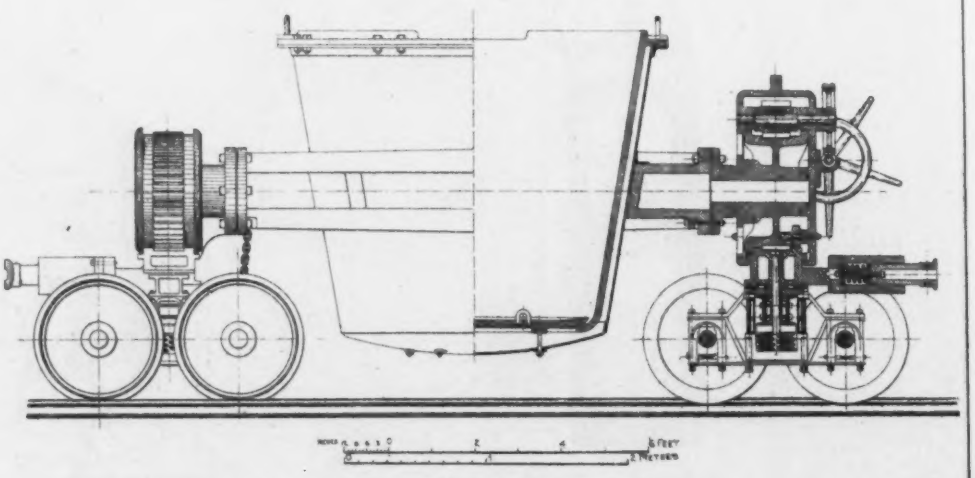


FIG. 27. 200 CU. FT. CINDER LADLE CAR.

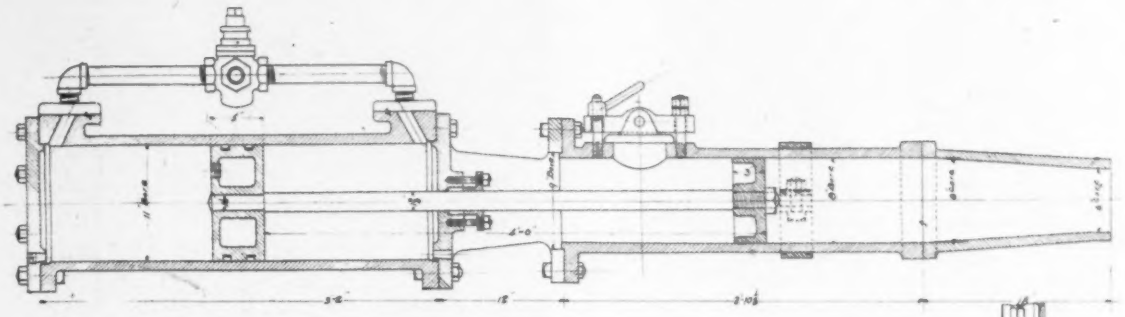
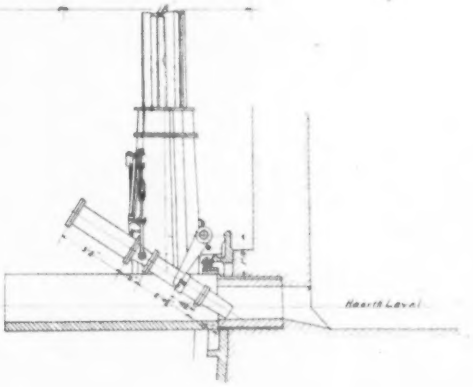
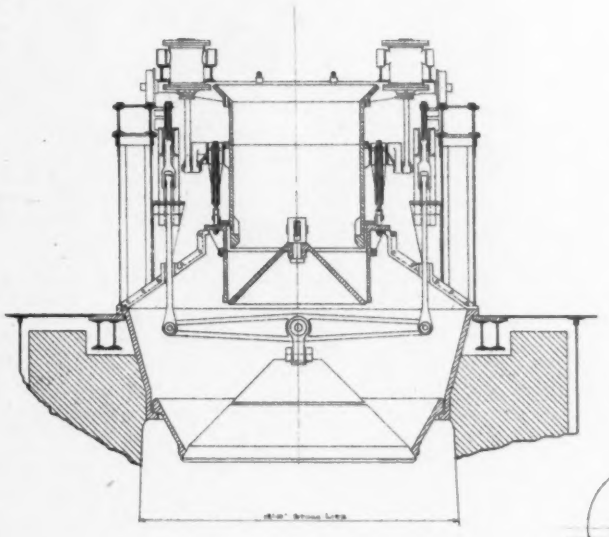


FIG. 28. TAPPING-HOLE GUN.





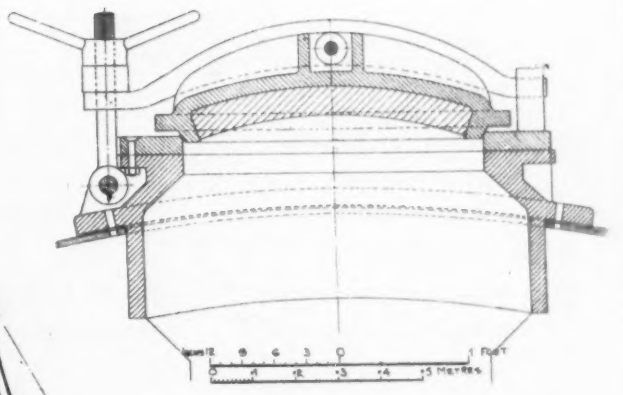


FIG. 34. GAS-OPENING DOOR.

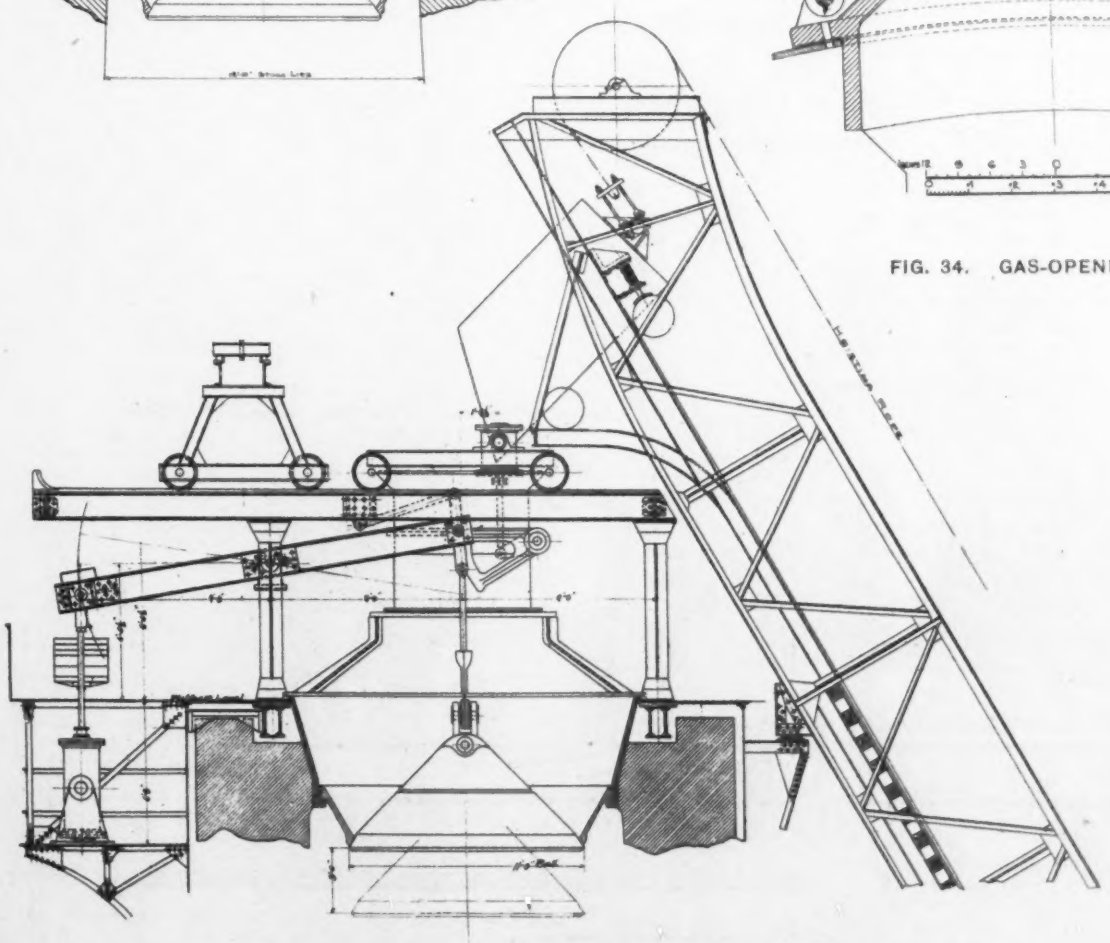


FIG. 22. FURNACE TOP.

FIG. 30.

LINES OF FURNACE No. 1 AFTER BLOWING OUT.

FIG. 31.

LINES OF FURNACE No. 2 AFTER BLOWING OUT.

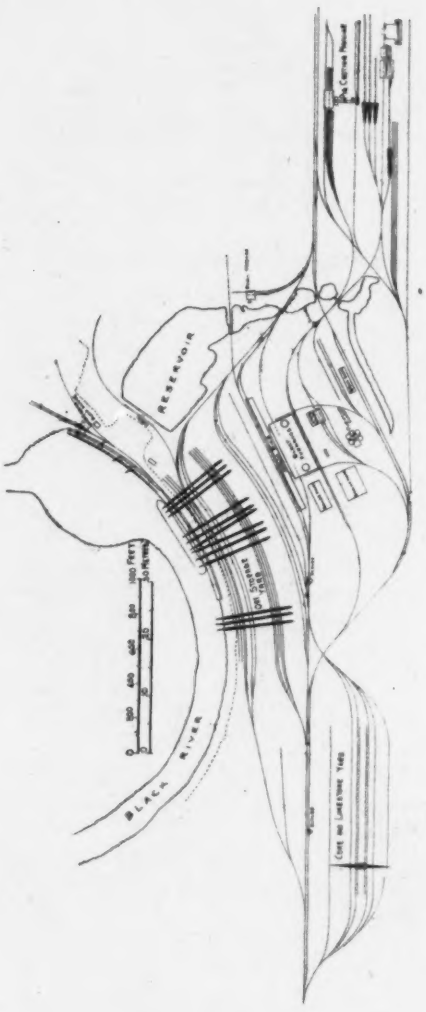


FIG. 35. PLAN OF FURNACE YARD.

FIG. 33.

Fig. 33 a. Fig. 33 b.

EXPLOSION DOOR JOINTS.

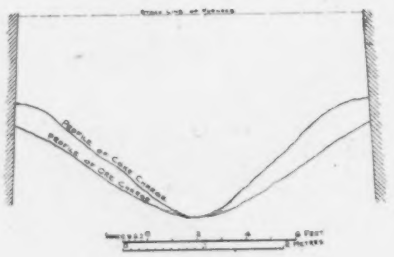


FIG. 32. STOCK PROFILES.

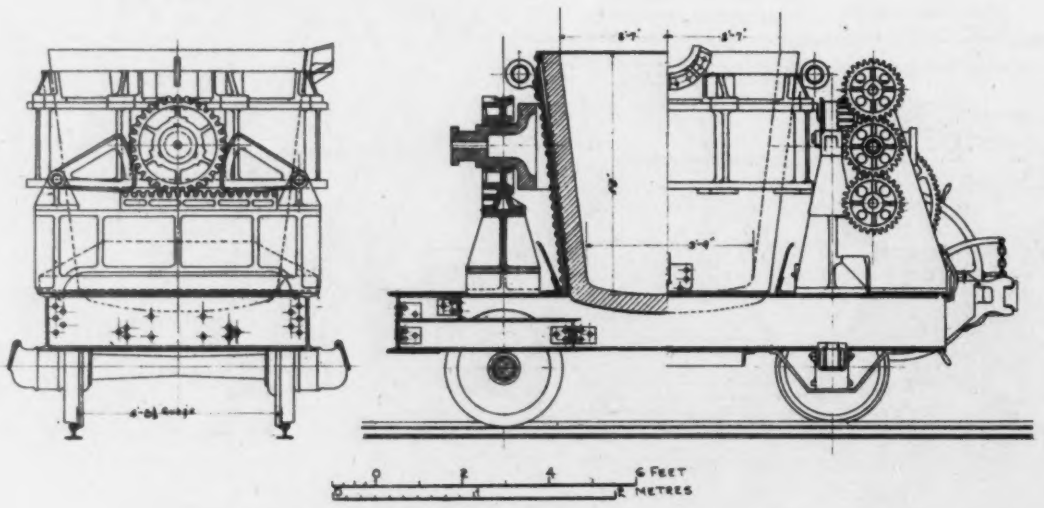


FIG. 26. 15-TON HOT-METAL LADLE CAR.

are smoked by two smoke furnaces just before they pass over the tail sprockets. A set of chills will, under ordinary circumstances, last for nine months or a year. In cold weather, however, it is necessary to heat the water in the tanks, otherwise the repeated sudden and violent difference of temperature soon cracks the chills. The ladles are tipped by an electric ladle-tipping machine, from the spindle of which a connection is made with the hand wheel on the ladle car. Provision is made for casting in sand-beds at the furnaces, using the space inclosed by the retaining walls between the two stacks and opposite the stoves; but this is done only in case of accident to the casting equipment.

Fifteen-ton ladle cars, Fig. 26, plate VIII., are used to convey the molten iron from the furnaces to the pig-casting machine. By referring again to the general plan it will be seen that these stand in a row on the hot-metal track which runs along the front wall inclosing the furnace foundations, and that the iron runners from the tapping holes terminate in spouts at a sufficient elevation to allow the iron to pour into the ladles. Similarly, the slag runners have spouts projecting over the cinder track, which is parallel to the end retaining wall. The cinder ladles, Fig. 27, plate VI., are of 200 cu. ft. capacity, and have removable cast-iron linings, which can be renewed when worn out. The furnaces are tapped six times per day each, drawing off 100 tons of iron at each cast when working at their full capacity. The tapping hole is stopped up after the cast by means of a steam tapping-hole gun, which is shown in Fig. 28, plate VII., as is also its method of use. It is suspended from a small jib crane attached to one of the furnace columns, and can be swung out of the way when not in use.

When the iron from the furnaces is to be used direct in the steel mill without remelting, the ladle cars containing the molten metal are taken to the mixer building, which contains a large mixer or storage tank which is capable of holding 300 tons of molten iron, and the general design of which is shown in Fig. 29, plate VI. Here the ladles are lifted off the cars by an overhead electric traveling crane, and the iron is poured into the tank, which serves the double purpose of a reservoir from which the steel works can draw their supply and also of insuring a very much more uniform grade of iron, since all casts are mixed together. The mixer itself can be tilted by hydraulic cylinders to pour the iron into the steel works ladle. The iron is kept from chilling by means of fuel-oil burners inserted in the doors placed on the center of rotation and in the pouring spout.

Furnace No. 1 was put in blast July 5, 1899, and blown out July 14, 1900; furnace No. 2 was blown in Aug. 23, 1899, and put out of blast July 19, 1900. During these periods No. 1 made 162,687 tons of iron, and No. 2 made 132,290 tons. They were seldom worked to their full capacity. Figs. 30 and 31, plate VIII., respectively, show the lines of the furnace walls obtained by actual measurement immediately after cooling off; measurements were taken at four points of the compass, as indicated in the figures. It will be seen that the diameter of the bosh has increased considerably for the short blast; bronze plates in place of the cast-iron coolers would probably have held the lines better at this point, and several new furnaces are being so equipped. The cast-iron rings protecting the stock lines were found to be badly warped inward; in many cases they had drawn the brickwork with them. This was probably caused by the high temperature at the furnace top when blowing out. However, it is very doubtful as to whether these rings are of any practical value. If they are used at all, they should be made light enough to prevent their warping from drawing the brickwork. There is a good deal of wear on the stock lines, as will be realized by referring to Fig. 32, plate VIII., which shows the profiles of stock as delivered by the bell; but with unprotected walls this would be evenly distributed all the way round, and the movements of the stock would probably be more regular on account of having no projections on the walls. The action of the bell and seal were very satisfactory.

The operators' houses were originally placed over the incline on each furnace top, which necessitated keeping two men in each house on account of danger from escaping gases, but later a single house was placed on the center of the stove platform, from which the bell apparatus for both furnaces was operated with much less expense and greater immunity from danger. The furnace top is equipped with six explosion doors placed directly under the platform. This proved to be a serious defect, as whenever gas leaking from these became ignited the mantel and platform were often badly warped by the heat; and in one instance the frame carrying the incline was also badly bent. This demonstrates the necessity of carrying the explosion-door frames out from the furnace clear of everything. The joints of these doors were originally made as shown in Fig. 33, plate VIII., but after the furnaces were blown out they were changed as shown in Fig. 33, b, plate VIII. The surfaces in this case were machined, and the door and frame brick lined. The value of asbestos packing for doors that open frequently is very doubtful, as it soon becomes dry, hard and lifeless, which makes the prevention of leakage impossible. In another of the large furnaces recently built in this country the joints of the furnace-top explosion doors were simply plain, flat, machined surfaces.

The cooling system of the hearth jacket was soon rendered ineffective by the stopping up of the pipes, due to leakages and small breakouts of slag from the bosh walls, which made it necessary to spray water on the outside of the jacket. The depth of the jacket is also unnecessarily great, and perhaps the only advantage of this type of jacket is that a section can be replaced when damaged by a breakout or other cause. The average amount of cooling water used for both furnaces was about 7,000,000 U. S. gallons per 24 hours. This includes that used in the furnace-cooling system, and in the seats and discs of all water-cooled valves. The average rise in temperature of the water was 10.5° F. From these figures we may arrive at a very close approximation of the amount of heat carried away by the water. A complete system of cast-iron runners for the hot metal was originally installed, but this was soon found to be useless and was dispensed with except at the spouts. There is a great difference of opinion in regard to the use of cooling plates below the tuyeres; many claim that the tendency to chill the iron is too great, but it may be said that they were used with very satisfactory results in these stacks.

It is remarkable to what a small extent furnace designers have been guided by experience in the construction of heating stoves. Very many of the largest furnace plants have been badly crippled for long periods of time in order to allow the stoves to be reconstructed. The points of weakness are principally found in the plates forming the lower courses, and in the weakness of the stove fittings riveted to the shell. The plates of the bottom course in the Lorain stoves were ½-in. thick, and many of these were badly cracked soon after the furnaces were put in blast. It will be seen by referring to Fig. 19, plate IV., that all the pipe connections are made at the bottom, and that cutting away so much of the plate makes it very weak. For a stove of this size, therefore, a plate not less than ⅞-in. thick should be used. The flanges of castings, riveted to the stove shells, were about 1¼ ins. thick, of cast iron. Many of these were also broken by the heat —especially the gas opening door—which caused bad and annoying leaks. These fittings were replaced by heavy steel castings, and no further trouble was experienced. Fig. 34, plate VII., shows a gas-opening door that has been very satisfactory. It will be noticed that the joint is of the spherical type and that the door itself is brick lined, which is the only sure way of preventing it from warping. The stove gas burner was originally designed 22 ins. in diameter, with a 10-in. air-supply pipe, and the opening in the stove was made 28 ins. in diameter. This burner was found to use too much gas, so that there was not sufficient for the boilers. It was modified to the dimensions shown with very satisfactory results.

The hot-blast valve, Fig. 20, plate V., is much heavier than the one originally used. The lighter valves were a great source of trouble, and in replacing them all the cast-iron rings riveted to the shells were found to be cracked. All the castings, except the bronze water-cooled seats in the later valve, were of steel. On account of the hot-blast valve being opened and closed so frequently, and its consequently greater liability to get out of order, another shut-off valve should be inserted between it and the hot-blast main; otherwise a crippled hot-blast valve cripples the furnace, since no pressure can be carried in the hot-blast main. The longer branch made necessary by the extra valve is also of great advantage, in that more freedom is allowed for the expansion of the main.

The blast temperature could be easily raised to 1,200° or 1,300° F. with these stoves. With large percentages of soft ores in the burden, however, it is found that a high blast temperature causes a high-blast pressure. A 15-in. mixing pipe, connecting the cold and hot-blast mains, was often found to be too small to reduce the hot-blast temperature by the desired amount, and a larger connection had to be made. An automatic controlling device, used with great success at another of the large furnace plants, was also contemplated. This consists of placing in the mixing pipe a butterfly valve, which is electrically controlled from the pyrometer, to keep the temperature of the blast within certain limits. The power necessary to move the valve is supplied by the blast pressure. At the plant mentioned it was found to be possible to keep the temperature of the hot blast within 5° above or below that desired.

One of the greatest sources of trouble at these furnaces was the "whipping" of the cold-blast main caused by the pulsations of the engines. This is an annoyance to which too little attention has been paid at many furnace plants, especially when it is considered how easily it can be avoided. The mistake is often made of trying to hold the pipe against these pulsations by strapping it to some solid foundation, but this can result only in loosening the rivets and causing leaks. All that is necessary is to provide a receiver of sufficient capacity to break up the column of air and absorb the pulsations.

The commercial efficiency of a furnace depends primarily upon the cost of delivering the raw materials of ore, limestone and coke at the furnace top, and of getting rid of its product as pig or molten iron. This plant is admirably situated with respect to its ore supply, for the reason that the ore is unloaded from vessels directly to the stock piles without reshipment by rail. From the stock piles it is loaded by steam shovels into special pressed-steel hopper-bottom cars of 50 tons capacity, similar to the standard steel railway cars, but much shorter. These cars are then brought to the stock bins, and their contents are dropped through the hoppers, ready for use in the furnaces. Placing the stock bins underground has the advantage that no trestle with heavy grade approaches is required, but it is very doubtful whether the great cost of construction and maintenance is fully warranted on this account, as in cold weather the ore seems to freeze in them as readily as when placed in elevated pins. Limestone and coke are received by rail, and the coke is stocked by means of a traveling cantilever crane operating a grab bucket.

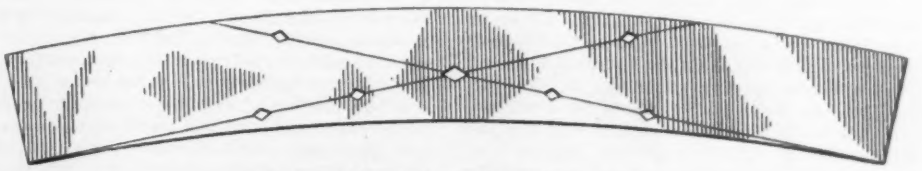
The plan of the furnace yard is shown in Fig. 35, plate VIII. All the tracks are of standard gage, and the sharpest curve is of 461 ft. radius. The hot-metal ladle car has a rigid wheel base of 7 ft. 6 ins., and the 461-ft. curve has been found by experience to be about as sharp as it can round. It is very important to have the tracks carrying hot metal as free from curves, grades and other complications as possible, as a ladle full of molten metal off the track is a very serious matter. It will be noticed, by reference to Fig. 26, plate VIII., that the ladle cars for hot metal are equipped with hand-tilting gear. This is certainly an unnecessary expense and complication for a modern furnace equipment. Wherever the ladle must be tipped—namely at the pig-casting machine, the mixer and in the ladle repair house—there are cranes at hand to do this, and the hand gear is a drawback rather than a help. Especially is this so at the mixer, where the ladles are lifted off the car and replaced thereon after pouring. A much more satisfactory ladle car would be one mounted on a pair of swiveling trucks, with simply the necessary supports to receive the ladle trunnions and a lock to prevent the ladle from tipping while in transit. A satisfactory ladle is one of the most necessary adjuncts to a modern furnace equipment.

NEW DEVICE FOR DRAWING RAILWAY CURVES.

Ordinary curves, cut from cardboard or made in rubber, have long been used for drawing railway curves of constant radius; but an improved form of these curves has been lately devised by Mr. Henry Q. Swenson, of St. Paul, Minn.

The curves themselves are made in the usual manner, with the arc of each adapted to various radii. The improvement consists in permanently marking on one surface of the curve lines tangent to the interior curve and starting from the lower ends of the curve; and at the intersection of these tangents and at points on the tangent lines openings are made through the curve so that it may be readily adjusted to the tangent lines drawn on paper. The tangent lines on the curve are drawn through the point of intersection and extended to the opposite edge, so that the curve can be used both ways.

This device is claimed to be exceedingly useful in the drafting room, as compared with the old,



A New Device for Plotting Railway Curves.

solid curves. By applying the curve-ruler to both ends of a long curve on a drawing, and by then uniting the curves thus made, an effective length up to three times the actual length of the implement can be secured. A tangent can also be readily laid off at any point on the circumference by pricking through the perforations; and from this tangent the radius may be found. As the tangent lines are practically as long as the curve-ruler, especially in the flatter curves, the device can be used in platting without any sacrifice of accuracy. The address of the inventor, Mr. Swenson, is 301 Endicott Building, St. Paul, Minn.

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We print in this issue a special eight-page supplement containing the most complete set of drawings relating to blast furnace construction that has ever been published, so far as our recollection extends. The drawings refer, moreover, to one of the newest of American blast furnace plants, that of the Lorain Steel Cp., which now forms part of the great U. S. Steel Corporation.

Perhaps it may be said that blast furnace construction is now of no particular interest to any one outside the circles of that gigantic combination, but we do not take just that view of the matter. On the contrary, it seems to us quite probable that the next few years may see a very considerable amount of blast furnace construction, by interests independent of the steel combination.

It is related of Andrew Carnegie that during the early '90's, when times were hard and when profit in the iron business was at the lowest ebb, according to common report, a friend one day accosted him about as follows: "Mr. Carnegie, everybody says that the bottom is knocked out of the iron business, and there's no longer any money in it. How is it that in such times you are actually building new furnaces?" "Yes," said Mr. Carnegie, "I am building some new furnaces, and I'm only afraid I won't get them done in time so that they'll pay for themselves this year."

It is a fact that there are few fields of manufacturing enterprise in which exist such possibilities of vast profit—and of loss—as in blast furnace operation. Take the plant of two furnaces illustrated in this issue. In the first year of their operation they made nearly 300,000 tons of pig iron. At present market prices this would be worth from $4,500,000 to $5,000,000. A profit of only $3 per ton on this output means net earnings of nearly a million dollars a year. When it is borne in mind how prices of pig iron swing up and down, it is readily seen how a blast furnace plant that is one day a bonanza may have to be put out of blast a few months hence to save its owners from bankruptcy.

Thus it comes about that in hardly any industry does geographical location count for so much as in blast furnace operation. The furnaces in the most favorable location, where fuel and ore and flux are cheaper than their competitors can obtain, can make enormous profits at times when their competitors are just able to make both ends meet. But the place of maximum economy for iron-making is subject to change. Exhaustion of ore deposits, discovery of higher grade ores, improvements in transportation, are among the causes which effect such changes. Pittsburg, for example, which has so long held first place as the center of cheapest production, is now probably surpassed by the shores of Lake Erie.

Who can say what changes the future may have in store; what new discoveries of iron ore in Texas, on the Pacific Coast, in the Rocky Mountains, in Canada, may create in the shape of new centers of economic production? Whatever these changes may be, we can be reasonably sure that the blast furnace will follow them. The owners of a furnace which is beaten a dollar a ton by another locality in cost of production can better afford to demolish their furnace for scrap and build anew in the new locality than to continue the old furnace in operation.

The United States Steel Corporation owns some of the best-located blast furnaces in existence; but in order to meet the expectations of its stockholders, it must make huge profits on its output; it must seek to maintain present prices of iron and steel. What is there to prevent outsiders from selecting the most favorable locations, and building their own furnaces? Enormous profit on such ventures is practically certain; the only difficulty in the way is the securing of ore and fuel supplies. It is yet to be shown, however, that the new combination has so secure a grip on coking coal and iron ore deposits as to prevent others from gaining a foothold, and the profit in sight seems sure to stimulate efforts in this direction.

The Canadian Society of Civil Engineers does not find it all plain sailing in its efforts to make civil engineering a "close" profession by legal enactment in Canada. Members of other Canadian engineering societies are strongly opposing the efforts of the Society to obtain the desired legislation and apparently with good success.

THE SUBSTITUTION OF MASONRY FOR CAST-IRON LINING IN THE SHIELD SYSTEM OF TUNNELING.

The use of segmental cast-iron lining for tunnels was first proposed by Mr. Peter William Barlow, in his patent for a new system of tunnel construction taken out in England in 1863. Previously no serious thought had apparently been given to any other material than masonry for lining soft ground tunnels. Sir Isambard Brunel, in constructing the first Thames tunnel in 1825-43, had used a masonry lining in connection with his now famous rectangular shield. The innovation from previous practice was probably suggested to Mr. Barlow by his extensive work in constructing cast-iron cylinder foundations, for his invention was a close application of cylinder foundation methods to the construction of horizontal passageways. It may be questioned whether Mr Barlow had much further reason for his selection of a cast-iron lining to accompany his shield system of tunneling than this precedent, and the fact that such a construction afforded special advantages for the use of compressed air, which was perhaps the controlling idea in his invention.

The first application of Mr. Barlow's shield system was made in the London Tower Tunnel, begun in 1867, and its success in this work was in a large measure due to the practical engineering ability of Mr. J. H. Greathead, with whom the inventor associated himself in his contract for the work. Mr. Greathead took the rather vague paper plans of Barlow and wrought them into practical shape. The precedent established by this successful combination of a circular shield with a segmental cast-iron lining was followed in future works of similar character prosecuted by Mr. Greathead and others, until it became to be accepted almost as a creed, that the two devices were inseparable. In only a few instances have engineers ventured to vary from this firmly-established practice and return to the use of a masonry lining in connection with shield excavation, and in each of these instances the tunnel built has been of small section for sewerage purposes. In view of these well-established facts, the proposition of Mr. Howard Carson, M. Am. Soc. C. E., to use a masonry lining in connection with shield excavation in the 23-ft. 20-ft. section of the East Boston Tunnel, which is described elsewhere in this issue, is a departure which will be noted with interest by engineers.

Both the advantages and disadvantages of using segmental cast-iron lining in combination with shield excavation are quite well known to engineers. It may not be amiss, however, to review them briefly here with the object of discovering what claims to merit a masonry lining presents in comparison. The advantages of cast-iron lining where tunneling operations have to be conducted under air pressure are obvious. No form of masonry lining of reasonable section serves the purpose so well. This fact was fully realized by Mr. Barlow, and, as his patent papers show, was one of the chief reasons why he adopted cast-iron lining in connection with his shield system.

The principal claim to merit which a cast-iron lining presents to tunnel builders is, however, its suitability to the work of driving the shield. When once a ring of segments has been erected and connected up, that much of the tunnel lining has been completed so far as structural strength goes. It affords from the beginning, therefore, a strong and stable abutment for the thrust of the jacks which drive the shield forward. Masonry lining, whether it be laid up with stone or brick or a monolith of concrete, requires considerable time to set and become strong enough to endure pressure without injury, and this precludes its use as a back support in driving the shield. The use of masonry lining in connection with shield excavation necessitates as a consequence an independent structure from which to propel the shield. In all instances where masonry lining has been employed in connection with shield excavation, the timber centering for the masonry arch has been made to serve this purpose. This is essentially the plan proposed by the engineer of the East Boston Tunnel. It is, of course, obvious that if the centering has to serve the dual purpose of an arch center and a rigid structure to resist horizontal thrust amounting in large shields to two or three thousand tons, it must be considerably modified from the usual construction, and that these modifications will add to the expense and difficulty of the timbering.

The possibility of devising some means whereby the back thrust of the shield jacks can be transmitted directly to the masonry without danger to its integrity has often been canvassed, but with no very encouraging results. One of the most familiar suggestions has been to convey the thrust of the jacks to a strong girder or to a series of segmental girders which would distribute the pressure evenly over the entire front face of the lining ring. The practical objections to this plan are numerous. A green concrete could never endure the pressure even if the thrust were distributed over the whole area of the lining. Indeed, this is so generally admitted that those who have proposed the use of the device named have usually stipulated that a lining of cut stone or artificial blocks should be used in connection. To use such lining materials successfully would require that full advantage could be taken of the exact dimensions of the blocks to secure thin mortar joints, and this is a difficult matter under the working conditions with which the mason has to struggle in laying the arch of a tunnel lining. It would also require the lining to be built in rings whose front faces were approximately true surfaces in the plain perpendicular to the axis of the tunnel. This also is a result which is not easily secured. Finally, we are confronted by the fact that the bearing girders must be of great weight and rigidity if they are to distribute the local pressure which will result from the individual use of the jacks to correct the

alinement of the shield. Altogether, therefore, engineers are probably warranted in setting aside as out of the question any proposition for distributing the shield thrust over the green masonry lining.

A third important advantage which cast-iron lining presents to the practical tunnel builder is its ease and rapidity of erection, and the comparatively limited space taken up by the erecting plant and construction materials. In these respects no practical form of masonry lining can expect to compete with cast iron.

So far we have presented only the advantages which cast-iron segments present as compared with masonry as a lining construction for tunnels driven by shields. No one, we presume, will gainsay that they are very important advantages, and that they warrant in a large measure the favor which this system of lining has received from engineers. Attention may now be turned to the disadvantages which the system presents.

The use of cast iron is practically limited to circular sections. The circular section for tunnels has the theoretical advantages of giving the greatest possible area of section for a given perimeter and of being the form best suited to withstand liquid pressure. Where the tunnel is to be employed as a sewer or other conduit for liquids the first advantage named is of great practical value, but this is not the case if the tunnel is to be used for railway or vehicular traffic. The second advantage is of doubtful practical value. Few submarine tunnels have been built where a circular section would have been adopted if its only merit had been its theoretical stability against external pressure. As a matter of fact, the laminated clays through which many Italian tunnels have been built is a considerably more unstable material than any of those through which modern shield tunnels have been driven, and here polycentric masonry linings have been used with perfect success. The truth of the matter is that in selecting the circular section for shield-driven tunnels engineers have been influenced chiefly by the belief that this was the only practicable form for tunnel shields. To what extent this belief is warranted is a debatable question. Certain facts are beyond question, however. The first of these is that in driving a tunnel under a river where it is important to keep the depth below the bed a minimum in order to reduce the grades, the circular section is objectionable for the reason that it necessitates the use of a vertical height for the section, a considerable proportion of which is not needed for the safe and comfortable passage of vehicles. The second fact is that other forms have been successfully employed for shields than the circular. In some of the recent Paris sewer work, elliptical shields were successfully used with the major axis horizontal, and having a ratio of seven to five to the vertical minor axis, while in both France and the United States flat roof shields have been used with perfect success, and with a material saving in the vertical height of the section. In view of the facts indicated, the suggestion seems warranted that, before engineers adopt a circular section for the sake of maintaining the circular form of shield, when it would not otherwise be adopted, they might well consider the possibility of varying the form of the shield. This in substance is what Mr. Carson has done in the case of the East Boston Tunnel.

Turning now to the question of durability and cost, we find that generally the available evidence is in favor of masonry as compared with cast iron. Speaking of the reasons which led to the selection of a masonry lining for the East Boston Tunnel, Mr. Carson says:

> In the matter of durability concrete has rather more chances in its favor than cast iron, and in the matter of cost the difference in favor of concrete where it is feasible to use it is very great.

The great force of this opinion rests on the fact that it is based on careful comparative calculations and studies made for the prosecuting of an actual work. In the very complete article describing the use of shields in constructing the Melbourne, Australia, sewer tunnels (Eng. News, Feb. 7, 1901), Mr. G. H. Dunlap, speaking of the use of voussoir-shaped concrete blocks, says:

> The concrete block system of lining was fully tried, and it must be admitted that it only partially realized the anticipation generally held when it was first introduced. Its advantages were such as to make it eminently suitable to our circumstances and worthy of trial. It was cheap, and if it could be effectively constructed it would be most reliable and durable. But it had two radical inherent constructional defects. As the shield was pushed forward, the joints partially set, were broken by the pressure used in shoving the shield, and by the alteration of form of the ring of blocks in passing out of the shield into the larger area of excavated ground. No means to sufficiently overcome these defects have yet been brought forward. If they could be overcome the merits of the system would be great, and its extended success assured.

It will be observed that the principal defect developed was the inability of the lining to take directly the back thrust of the shield jacks, which goes to confirm the opinion expressed in a preceding paragraph where this question is referred to. It is worthy of remark here that in the Paris sewer work a stone masonry lining was successfully used without the difficulties mentioned by Mr. Dunlap, by constructing the centers to take the thrust of the shield jacks. In this same work a very successful use was made of grout injected behind the lining to fill the void left by the tail plates of the shield. Basing his conclusions upon this Paris work, Mr. Raynald Legouez says:*

> In conclusion masonry lining is certainly economical in earths which do not require the use of compressed air. It offers the same qualities of rapidity of execution, strength and tightness as metallic lining, and it binds itself without difficulty to the shield method. It needs to be stated, however, that, with high pressures of compressed air, it presents serious difficulties and that a metallic lining would be more easy and certain in construction.

Basing his calculations upon French prices, Mr. Legouez estimates the cost of masonry lining for circular tunnels as from 94 per cent. to 43 per cent. of that of cast iron in firm soils, and as from 160 per cent. to 71 per cent. of that of cast iron in soft soils, the diameters running from two meters ot ten meters.

At first sight the comparative cheapness of masonry as compared with cast iron for tunnels of large section, which these figures indicate, seems questionable. A brief estimate will, however, show that the conditions have not been exaggerated. In the St. Clair tunnel the total cost of cast iron for lining was in round figures $800,000 for 6,000 lineal feet of tunnel, or say $133 per lineal foot. This did not include the cost of erection, or of placing the inner lining of concrete, some 6 ins. thick. The interior diameter of the tunnel is 20 ft., and a masonry lining 3 ft. thick with the same inside dimensions would require 3.75 cu. yds. of masonry per lineal foot. Portland cement concrete in the proportions of one part Portland cement, three parts sand and five parts broken stone will cost, mixed ready to be put in place, not more than $7 per cubic yard, or $3.75 \times 7 = \$26.25$ per lineal foot of tunnel of the same diameter as the present tunnel. The margin in favor of concrete is, therefore, $133 — $26.25 = $106.75 per lineal foot. Against this is to be debited the extra cost of laying the concrete; the extra excavation for the larger section, or say 3.78 cu. yds. per lineal foot, the extra cost of a shield of 3 ft. greater diameter, and the cost of the necessary arch centering. At the most liberal estimate these items may, perhaps, add $10 per cubic yard to the cost of the lining, making it $10 + $7 = $17, or say $20 per cubic yard as an outside figure. Even at this price, however, a concrete lining for the St. Clair tunnel would have cost only $450,000, as compared with the cost of upwards of $800,000 actually paid for the cast-iron lining material used. These figures are very rough approximations, but they err on the side of liberality toward cast iron, and yet show that this material is far more costly for tunnel lining than almost any character of masonry would be.

The bits of evidence which have been quoted indicate at least that the possibility of substituting masonry lining for cast-iron lining is not out of the reach of engineers as a structural problem. The question arises whether the change is worth while. The answer of the evidence quoted is strongly affirmative. For small sections the economy afforded by masonry is small, but as the section increases in size the percentage of saving increases; in sections of 33 ft. diameter it amounts, according to Mr. Legouez, to from 57% in firm soils to 29% in soft soils. These are economies which are worth seeking, since they extend very materially the present field of usefulness of the shield system of tunneling.

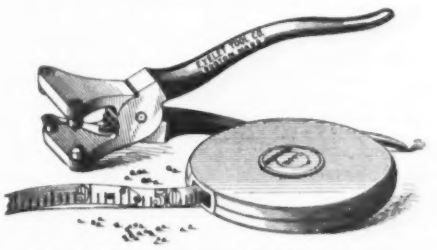
*"Emploi du Bouclier dans La Construction des Souterrains," Bandry et Cie, Paris, France.

LETTERS TO THE EDITOR.

A New Steel-Tape Mending Tool.

Sir: Having noticed with much interest an occasional article in the Engineering News in regard to mending steel tapes, I submit the following, hoping it may be of some value to the tape-mending fraternity:

After mending more or less tapes for a number of years by the old method of punching a hole with a shoemaker's awl, darning needle or a similar tool, and then inserting a solid rivet, the idea occurred to me of mending tapes by using a punch and set, and inserting an eyelet in place of a solid rivet. With this in mind, I purchased a tool from the Eyelet Tool Co., 40 Lincoln St., Boston, capable of punching a hole 3-32-in. diameter through two thicknesses of Chesterman steel tape. After experimenting, I found that 3-32-in. took too much metal from the tape in cross section; so I ordered another tool, capable of punching a hole 1-32-in. diameter instead of 3-32-in. This tool and its rivets are shown clearly in the cut. The mend shown took just four minutes to complete.



An Eyelet Tool for Mending Steel Tapes.

Quite a large number of engineers in this vicinity are adopting this method and writing testimonials in its favor. It is superior to the old method inasmuch as it punches a clean-cut hole; whereas the awl or needle leaves a ragged edge on one side of the tape which has to be filed smooth before the two pieces of tape can be riveted together.

In mending a tape, as shown in the cut, I lap the two pieces to be joined, taking care to have the proper graduations coincide; then punch the necessary holes; then separate the pieces, cut and file the ends to a neat appearing curve, as close to the holes as practical so as to not leave a free end to collect dirt or cut the fingers; then lap the ends again, placing the holes exactly as when first punched; insert and clamp the rivets, which completes the mend. Yours truly,

James Wm. Martin, Assoc. M. Am. Soc. C. E.
38 Oliver St., Boston, March 23, 1901.

Traverse Tables.

Sir: In reply to your correspondent, W. J. G., in your issue of March 21, I would state that I have used two traverse tables of the scope of the one he seeks; they are: "Tafeln zur Berechnung Rectwinkliger Coordinaten," by C. F. Defert, second edition, 1874. Berlin: Julius Springer, No. 2, Monbijouplatz. This is a book of 97 pages, 9½ × 12 ins. in size. I think it is one of the finest pieces of typography in the way of tables that I have ever seen. As an example of its use with angle of 77° 51′ and distance of 87.67:

	Cosine.	Sine.
80	16.838	78.208
7	1.473	6.843
.67	.140	.655
87.67	18.451	85.706

"Traverse Tables," by Richard Lloyd Gurden. London: Charles Griffin & Co., Stationer's Hall Court, 1880. This is a book of 270 pages, 9½ × 14½ ins. It is well bound, and is $7.50, not including the cost of transportation. This is a much larger book than Defert's and will give four places of decimals up to 100 of distance. It is not so convenient as Defert's, and the arrangement and the type are inferior to his. Taking the same example as above, Gurden's tables will give:

	Cosine.	Sine.
87	18.3110	85.0512
.67	.1410	.6550
87.67	18.4520	85.7062

Defert's tables give supplementary tables for use when the seconds of angle are to be employed, and these tables are carefully given in duplicate so that one set may be mounted on cardboard while the other is bound in the book, a praiseworthy feature. If the seconds of arc are to be reckoned with Gurden's tables, the use of the slide rule will be found very convenient and it is equally convenient with Defert's.

Gurden's tables are for each minute of arc and distances from 1 to 100. Defert's tables are for each minute of arc and for distances of 10, 20 to 90 and with subtables for the decimal of two figures from 0.01 to 0.99 For the distance 10 with Defert's tables, the decimal is carried one place more than for the other numbers so that there will be no loss of precision in using arguments over 100 of distance.

I would add that I prefer to use five place logarithms, especially if the angle is given to seconds, and the tables

of F. G. Gauss are the best. The above example may be arranged for logarithmic computation as follows:

	1.93301	85.706
77° 51' sine	9.90016	
87.67	1.94285	
77° 51' cosine	9.32319	
	1.26604	18.452

Very truly yours, Horace Andrews.
51 State St., Albany, N. Y., March 22, 1901.

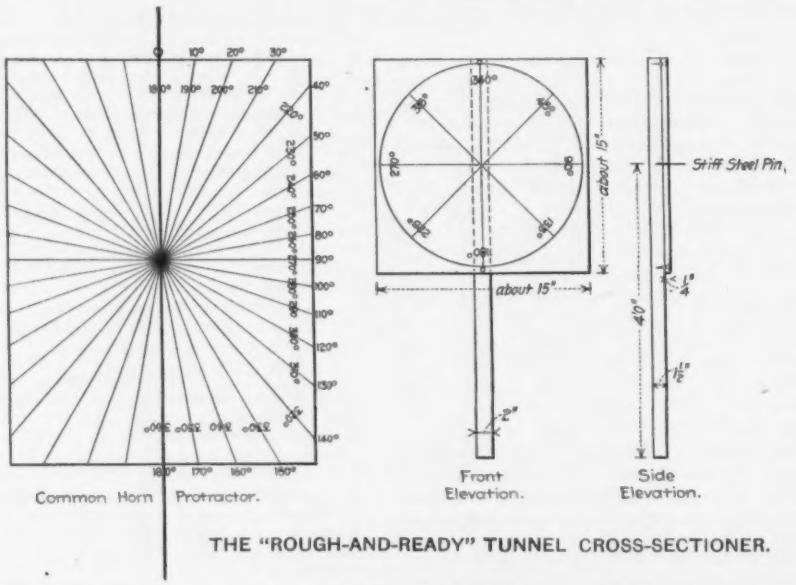
(Several other correspondents recommend Boileau's tables. Engineering News' Book Department states that it can supply the above works at prices as follows: Defert, $2.65; Gurden, $7.50; Gauss' Logarithms, 85 cts.; Boileau, $5. The last-named work is carried to five decimal places; still another work, which is carried to four places of decimals, is "Louis & Caunt's Traverse Tables"), price, $2.—Ed.)

A Rough-and-Ready Tunnel Cross-Sectioner.

Sir: Reading in your issue of March 14 about the "Sunflower Cross-Sectioner" and recognizing its good qualities, I submit a sketch and a few explanatory remarks regarding a "Rough-and-Ready Cross-Sectioner" which I made up and used on the tunnel work here.

The idea may be as old as the hills, as I am not familiar enough with tunnel work to know just what has been done along this line; but from tests made with this design I am fully satisfied that results approximately correct can be obtained. As nearly correct as can be expected with a perimeter as irregular as is an ordinary tunnel section.

I pasted one of Keuffel & Esser's 14½-in. transparent



THE "ROUGH-AND-READY" TUNNEL CROSS-SECTIONER.

paper protractors upon stiff cardboard and then fastened this upon a smooth piece of perfectly flat board, about ¼-in. thick by 15 ins. square; and this I fastened to a pine rod, the center of the circle being 4 ft. from the bottom of the rod at all times. Points in the tunnel were selected at which cross-sections were desirable; the alinement was fixed and marked and the elevation of the same ascertained and noted and the cross-sections were then taken as follows:

One man carried the rod with protractor attached as noted; one man kept the notes and one handled the measuring stick, which was made of a light straight piece of pine about ⅛ × 1 in., divided into feet, tenths and half-tenths and numbered plainly. The man with the protractor rod set the foot of the rod upon the point of which the alinement and elevation had been ascertained as previously described, plumbing the rod by balancing it between his fingers. The man with the measuring stick placed the zero end of the stick at such point in the perimeter of the tunnel as desired, resting the stick upon the steel pin at the center of the protractor, and easily and rapidly read the angle and distance.

The notes were readily plotted up with a common transparent horn protractor; and there never was the slightest doubt about the direction of an angle, as the protractor on the rod read from 0 to 360°, which is better, I think, than from 0 to 180°, on each side of the vertical line, as in the device illustrated in your issue of March 14. The device is perfectly simple, is quickly put together and gives good satisfaction as to results. A small level attachment for plumbing the rod would improve it.

Cyrus F. Sproul,
Jersey City Water Supply Co., Boonton, N. J.,
March 16, 1901.

The Canal Problem in New York.

Sir: I have followed the canal discussion in New York State with a great deal of interest since 1894.* Although six years have since elapsed, the problem seems as far from a final solution as ever, and to a layman the subject would seem to be exhausted, and that the time had come for action: that some one of the various projects should be adopted or that the canals be definitely abandoned. But, as you have pointed out in your interesting editorial of March 21, it is all but certain that no definite action will be taken in the matter for some time to come, and the subject is, therefore, open for discussion, and it certainly should be discussed with greatest freedom.

In 1894, Mr. Thomas C. Clarke, Past President Am. Soc. C. E., published in the "Transactions" of the Society, a paper which seemed to have for its object the purpose of showing that no radical change in the present canal system was physically possible.

Being somewhat familiar with the canals and not agreeing at all with Mr. Clarke's conclusions, I made a preliminary investigation of the subject, and reported to the State Engineer that there appeared to be no great topographical difficulties in the way of radical improvement, and that the cost would not be excessive for a work of such magnitude.

Since that time, two exhaustive surveys have been made, covering the whole range of possible projects. One was made by the U. S. Board of Engineers on Deep Waterways at a cost of something like $500,000 and covering two years of time; and one has just been completed by the State of New York at an expense of $150,000, and covering a period of one year.

In addition to these surveys, two exhaustive investigations of the subject have been made—one by the United States Deep Waterways Commission, and one by ex-Governor Roosevelt's Advisory Commission.

All these expert bodies of men have agreed as to the practicality of overcoming all engineering difficulties encountered, and estimates of cost have been prepared that are as accurate as it is in the nature of human efforts to be.

We are now offered a choice of projects which cover the whole field, and it remains to make a decision, to select one project and carry it out, or to abandon them all. This, as you have many times pointed out, is the greater problem. Will any one of these projects pay? If two or more will pay, which will pay best? But I do not agree with you that this is an engineering problem, for, until some one has plotted the industrial and commercial developments of the nations, written the equation of their curve, and solved it for the year 1950, the laws of engineering cannot be applied to the case.

Much time and energy has been devoted to estimates of future traffic, and its comparative cost by rail and water. That these estimates are but the crudest sort of a guide can be shown by similar forecasts for other great works. It often happens in a case of this sort, that the hopes of the promoters are greatly exceeded, or that they are wholly unfulfilled. In other words, accurate forecasts of future traffic and its costs cannot be made by mathematics.

The most sanguine of the canal advocates can point to a return of 3% on the investment as the fulfilment of their hopes, at least if they argue on the basis of direct financial returns. Now do you know anyone who wants to loan $20,000,000 or $200,000,000 on an uncertain chance of earning 3%? If so, please take me into your confidence. I would be a borrower.

You have argued against the canals, that the tendency of railway rates is downward, and that future developments in rail transportation will bring them so low that water routes cannot compete with them. Is it in the nature of things for a railroad company to take the public into its confidence and boast of the low cost of handling freight? Do they voluntarily reduce their rates? Has not the tendency in freight rates been upward for more than a year?

When the Union Bridge Co., at Athens, Pa., built the Jacksonville bridge in Florida, did it ship by rail or water, and why? Is Maine granite shipped to New York by rail or boat, and why? When manufacturers or merchants in New York have shipments for Gulf ports, they ship by water. The route is longer but it is cheaper.

The Reading Iron Co., at Reading, Pa., ships ore from northern Michigan by water to Buffalo, and by rail from Buffalo to Reading. Do you think the freight would cost as much if they could ship ore by water to Poughkeepsie, N. Y., and then by rail to Reading?

In the fall of 1899, there was a great stagnation of traffic because the railroads had more freight than they could handle, and there is trouble of the same kind every fall in a lesser degree. Does such a condition tend to reduce rates?

You have pointed out correctly that the canal agitation in New York has been due largely to parties who are looking for personal gain. I would add also politicians, who are looking for fuel to run their machines, and a few large-minded patriots who are seeking the welfare of the state. In the latter class is the Rev. Lyman Abbott, who wrote the Canal Advisory Commission that New York's interests would best be served by a barge canal along the route of the Erie, and not by a deeper canal, because in the former case cargoes must be transferred at Buffalo, and New York, and the citizens of the state could exact a toll, while in the latter case, New York would be only a way station, as it were.

To me the problem appears to be one of the broadest national statesmanship, and should be approached with a full knowledge of the historical industrial growth and development of the nations. The fate of this possible commercial highway should not be decided by elevator men and politicians, nor by the local needs of New York, nor yet by the standard of money lenders.

The industrial and commercial activity of the United States is concentrated in the highest degree in the region of the Great Lakes. That this wonderful activity will be greatly increased, there is no one who doubts. Consider the growth of the region in the past 50 years, and try to imagine conditions which will exist 50 years hence. Shall we seek to stimulate and aid this growth, or to hamper it and confine it, so that it will be driven to other territory? Existing railways will be wholly unable to handle the traffic 50 years hence, and if the growth continues at the same rate, one is almost tempted to say that enough railways to handle the traffic could not be built.

Would anyone to-day, standing at the New York approach to the Brooklyn Bridge at 8.30 a. m., and watching the multitudes of people entering the city for the day's work doubt the wisdom of constructing that great bridge? And yet, it had its season of promotion, of doubt and uncertainty and trials.

Would anyone doubt the wisdom of connecting by rail two such centers of wealth, industry and population as New York and Philadelphia? And yet, there was a day of uncertainty and doubt, when wise men were skeptical and moneyed men were cautious.

And now we have the traffic of the Great Lakes, which in the whole world is without a parallel, and the majority of the wealth, population and activity of the nation located in a tributary country; we have this traffic and industrial activity on the one hand, and all the cities of the Atlantic coast line on the other, which can be given greatly increased facilities for traffic by an adequate canal through the state of New York.

Is it unreasonable to expect that such a waterway would so stimulate traffic and manufacture, that in the course of say 50 years, the nation would be the gainer by its construction? The great benefits to be derived from a canal that would pass the lake fleet have been mentioned many times, but the attention has been so riveted on the mills per ton-mile that the vision cannot take in the perspective of new industrial plants, new traffic and new cities, which should furnish the real reason for building the canal.

It is popularly supposed that the railways are arrayed against the canal, and it is not improbable that such is the case, but should the opening of the canal be followed by the increase of business and population, the expectation of which should alone justify its construction, the railways would have all the traffic they could handle. In fact, the time is coming when every available route to the seaboard will be imperatively demanded to handle the country's traffic.

It seems a little strange that so little has been heard of the work of the U. S. Board of Engineers on Deep Waterways. Their report was available to the press last fall and a few brief abstracts were published. The proof was being corrected in January, and copies of the report should now be ready for distribution. The public is eager to read its contents, and many times since the Board began its work the question has been asked: Why is it kept so quiet? Why do we see so little of it in the papers?

If the canal had received half the advertising given the

*Since the Constitutional Convention of 1894, when steps were first taken to secure the $9,000,000 appropriation.

Nicaragua Canal, the people would demand its construction. The public is interested in it. It is an internal improvement of real merit, which promises practical results, and is a much-more worthy project than the numerous small jobs in the River and Harbor Bill on which millions are annually frittered away with no visible gain to the nation.

In regard to the size of the canal, barges of 1,000 tons capacity can safely navigate the Great Lakes in some kinds of weather. That has already been done; but the aim of boat-owners is to build large enough so that the boats can continue on their course in stormy weather and lose no time. Few of the present fleet can ignore a November gale, and any proposition to do business on the lakes with 1,000-ton barges is ill-considered. It follows, that a canal to avoid transfers, and to afford the largest degree of usefulness, must pass a boat drawing approximately 20 ft. of water. Such a boat could take a cargo from Chicago to Maine or Florida, or to Cuba. It is not improbable that the Illinois Steel Co. would like to ship rails direct to Cuba by water in spite of the fact that it, as well as the railways, are controlled by Mr. Morgan.

The construction of such a canal would undoubtedly be of great value to New York state. If the canal were built, there would be no finer site in the country for an immense steel plant and shipyard, than the south shore of Oneida Lake. The numerous water powers created along the Mohawk and Oswego rivers would be worth large sums of money, for the Board of Engineers planned to store sufficient water for lockages to avoid interference with the average flow of the streams, and this average flow must fall over a dam at the end of every canal level or be utilized in power. But greater benefits would accrue to the states bordering the Great Lakes, and there is no reason why New York state should bear the expense. It should be a national enterprise, and if New York should show a disposition to co-operate by offering the use of such portions of the state canals as would interfere with the location of the larger channel, nothing more could be asked of her. The present Erie Canal from Tonawanda to Syracuse could be maintained and the larger canal down the Mohawk Valley would better accommodate the local traffic.

The real problem now is: Would a 21-ft. channel between the lakes and the Hudson be such a stimulus to manufactures and commerce in the lake region, as to warrant the investment by the nation of say $200,000,000 in a permanent transportation route?

We have admired the sagacity and skill of the Roman in connecting the outlying portions of their Empire with roads that were marvels of constructive skill. The influence of free and unrestricted intercourse between remote districts in maintaining friendly feelings cannot be overestimated. No other nation ever has and probably never will construct a highway of such great importance to its country. We have the opportunity. Shall we put in a rainy day mending our fences; that is, bettering our great national farm; or, at some future day, watch our neighbor's cows eat up the corn which we have raised? What say you?

I am, very respectfully,

Albert J. Himes.

226 Hickox Building, Cleveland, O., March 26, 1901.

(Briefly summed up, the alternative plans for water routes from Lake Erie to the Harlem are as follows:

1. Governor Odell's plan to complete repairs on the old Erie Canal at a cost of $25,000,000.
2. The Greene Commission's plan to make a new canal for 450-ton barges at a cost of $20,000,000.
3. The Greene Commission's plan for a canal for 1,000-ton barges as perfected by State Engineer Bond; estimated cost, $50,000,000.
4. The 21-ft. deep waterway recommended by the U. S. Deep-Waterway Commission to be built by the United States at a cost of $200,000,000.

The last-named project seems to us much more likely to be realized than the others, which place the entire burden on the taxpayers of New York. It could at the present time, it is probable, command a very large vote in Congress. Its realization, however, would mean the entire loss of all New York might invest in the other schemes; and this is one reason among others, why any and all of them are pretty sure to suffer defeat.—Ed.)

Notes and Queries.

J. G., New York city, is referred to the annual statistical reports of the Interstate Commerce Commission.

R. P. S., Cincinnati, O., inquires what is the greatest number of lines ever ruled to an inch; on what material they were ruled, and how they were ruled?

As far as we are aware, the machine constructed by Professor Rowland, of Johns Hopkins University, has produced the most remarkable results in the production of diffraction gratings, as they are called. Some years ago this machine had ruled as many as 43,000 lines to the inch, and it has very likely exceeded this record since. Diffraction gratings can be ruled on glass with a diamond point or on plates of nickel, silver or speculum metal.

AN ENGINEERING TRAINING SCHOOL, within its own works, is proposed by the American Bridge Co. As outlined in the Pittsburg "Dispatch," the scheme is as follows: To take students and graduates from grammar schools and accept them as apprentices for four years, after a probationary period of 90 days. These apprentices would receive $3.50 per week for the first year; and an increase of $1 per week for each of the remaining three years, or $6.50 at the end of the period. These apprentices must bind themselves to remain the full period; and at the end of the course they will be entitled to a bonus of 50 cts. for each week they have served, or $104. Preference will be given to lads having a manual training or high school education; and graduates of engineering schools will be given employment at $12 per week. The company's engineers are to instruct the apprentices in drafting and in the various engineering and technical branches, somewhat on the same lines as the instruction now given in the East Pittsburg Works of the Westinghouse Electric & Manufacturing Co. It is expected that in this manner the company can in time secure a corps of exceptionally efficient young draftsmen, well grounded in the methods and practice of the company and especially fitted for the work of the company in its various departments. The objections to the scheme come from some of the older draftsmen, etc., who see in the projected school a plan for ultimately displacing them.

THE NORMAN MEDAL OF THE AMERICAN SOCIETY of Civil Engineers has been awarded to James A. Seddon, M. Am. Soc. C. E., for his paper upon "River Hydraulics." Mr. Seddon for nearly 20 years has been making a study of the physical conditions of western rivers, and is now hydraulic expert to the Sanitary District of Chicago.

THE PACIFIC MAIL STEAMSHIP "KOREA" was launched at Newport News on March 22. This is the largest vessel built in this country, and a sister ship, the "Siberia," will be ready for launching in the same yard in about one month. The "Korea" is 572.3 ft. long over all, 63-ft. beam, 40-ft. deep, 27-ft. draft, and has a displacement of 18,000 tons. The ship has four full decks, besides the orlop and boat decks. She has two quadruple-expansion, vertical-inverted, direct-acting engines, designed to develop 18,000 I. HP. at 86 revolutions per minute. Her nine boilers are of the Scotch type. She has cabins for 200 first-class passengers, and can carry 1,200 steerage passengers. The two steamships are to cost $2,000,000 complete, and they will run between Hong Kong and San Francisco, calling at Honolulu, Yakohama and Nagasaki. The contract speed is 18 knots, though it is expected that they will make 20 knots.

THE STEAMSHIP "KRON PRINZ WILHELM," of the North German Lloyd Steamship Co., was launched at Stettin on March 30. This vessel is to ply between Bremen and New York; she is 15,000 tons register; is equipped with engines of 32,000 I. HP., and is expected to maintain a speed of nearly 24 knots across the Atlantic.

THE ANTARCTIC SHIP "DISCOVERY," recently launched at Dundee, and which will sail in August on magnetic survey work in the Southern Seas, is built entirely of wood, as iron would interfere with the primary object of the expedition. To butt the ice, 9 ft. of solid oak make up the bow of this ship, and the sides are also of solid oak 2 ft. 6 ins. thick. Strong transverse bulkheads will resist the "nip" of the ice-sheets, and the hull is so formed as to lift under this pressure. The rudder and screw-propeller can both be hauled on deck when occasion demands. The interior of the ship is entered through a form of air-lock, so as not to disturb the even temperature within; and the ship will carry food for 40 persons for three years. Capt. R. F. Scott, R. N., will command the "Discovery," and with him will go Prof. Gregory, of the Geological Department of Melbourne University, as chief of the scientific party; Mr. Shackelton, physicist; Mr. Hodgson, biologist, and Dr. Koettlitz. A German ship, built on the same lines as the "Fram," will sail with the "Discovery" and assist in her work.

A STEAM-SHOVEL CONVERTED INTO A DREDGE is the novel idea worked out by General Superintendent John H. Harris, of the Choctaw Railway, for obtaining ballast material. Gravel is the only suitable material found in the neighborhood of his Arkansas railway, and this is in the beds of streams which are nearly dry nine months in the year. To obtain this gravel Mr. Harris constructed a barge, with a deck 20 × 50 ft., and upon this he securely mounted upon a track a steam shovel, weighing 78,000 lbs., with a dipper of 1½ cu. yds. capacity. The barge draws 27 ins. of water and the shovel can easily dig a channel 7 ft. deep. In operation, as the shovel is run forward on its track the bow of the barge sinks and practically rests on the bottom; though, for precaution, four 10 × 10-in. spuds at the corners of the barge, holds the barge stationary after that. As the gravel is dug it is unloaded onto cars on a temporary track on the bank alongside connecting with the main line. After the "dredge" has exhausted the gravel within reach, the steam shovel is moved back on the track, the bow rises and the barge is advanced and again secured by the spuds. The shovel thus digs its own channel, and as each heavy rain and the consequent floods wash the gravel back into this channel, the supply is practically inexhaustible. Instead of 12¾ cts. per cu. yd., as formerly, the gravel ballast now costs less than 4 cts. per cu. yd. The barge cost less than $1,000 without the steam shovel.

THE ROGERS LOCOMOTIVE WORKS, at Paterson, N. J., were sold, on March 25, to a New York syndicate with names withheld. Col. Jno. R. Beam, counsel for the receivers, says that the purchasing company will probably double the capacity of the plant, and it is now endeavoring to secure more property adjacent to the works. They may buy the old Grant Locomotive Works, which adjoins the Rogers Works, and were recently secured by the Paterson Trolley Co. as a car shed.

THE TELEPHONE was invented by Professor Bell 25 years ago, and at the meeting of stockholders of the American Telephone & Telegraph Co., on March 27, Acting President Cochrane gave the following general statement of progress: Twenty years ago there were 47,880 telephone subscribers in the United States, and 29,714 miles of wire. On Jan. 1, 1901, there were 800,880 exchange stations and 1,961,801 miles of wire in use. Of the total mileage of wires, 705,269 miles were underground, though only 70,334 miles were thus disposed of in 1892. The company now has 32,837 employes in connection with 1,348 exchanges and 1,427 branch offices. In the period 1892-1901 the total length of wire increased from 266,456 miles to the length named above.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF ILLINOIS.—The following course of lectures, under the auspices of the Mechanical and Electrical Engineering Society, will be delivered by non-resident lecturers during the current spring semester: "The Handling of Materials by Means of Endless Elevators and Conveyors," by J. V. Schaefer; "From Mine to Furnace," by John Birkinbine; "Steam Boiler Efficiency," by Wm. Kent; "Recent Developments in Central Station Lighting and Power Supply," by P. Junkersfeld; "Some Important Considerations in the Design, Manufacture and Use of Transformers," by W. A. Layman; "Alternating Current Power Work," by T. P. Gaylord; "Central Power Station Design," by Bion J. Arnold; "Locomotives at the Paris Exposition," by L. P. Breckenridge.

PURDUE UNIVERSITY.—The annual inspection trip of the Mechanical, Electrical, Civil and Chemical Engineering students this year was devoted to visiting various engineering plants and works in and about Chicago. The trip, which lasted four days, commencing March 25, included attendance upon the Alumni Banquet of the graduates of Purdue at the rooms of the Chicago Athletic Association.

UNIVERSITY OF KANSAS.—This University has organized a School of Mining Engineering, which will be under the direction of Erasmus Haworth, at present Professor of Physical Geology, Mineralogy and Mining. Metallurgy will be taught by Prof. H. P. Cady, and Mining by Dr. W. R. Crane.

COLORADO AGRICULTURAL COLLEGE.—A short course in Water Administration and Measurement, especially intended for the needs of water commissioners and superintendents, was opened on April 1. The course will cover the methods of measurement from streams into canals, the use of current meter measurements from canals, methods of administration and a discussion of laws and decisions as they affect the duties of commissioners.

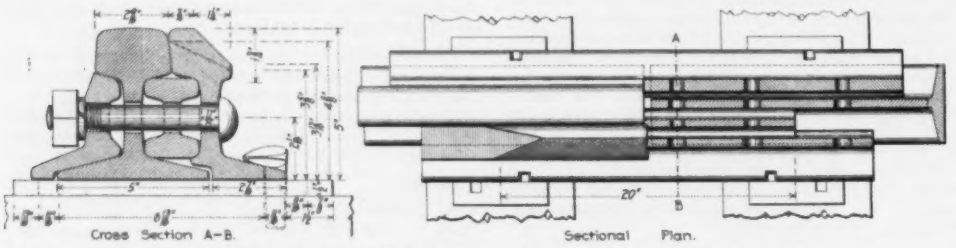
UNIVERSITY OF PENNSYLVANIA.—A gift of $25,000 has been received from Burnham, Williams & Co., of the Baldwin Locomotive Works, for the projected engineering department which the trustees have decided to establish.

UNIVERSITY OF MICHIGAN.—The Michigan Gas Association fellowship at the University was renewed for the year 1901-1902 at the annual meeting of the association, held in Grand Rapids recently; $600 was provided, $500 of which is paid to the holder of the fellowship, and the remaining $100 is used for the purchase of special apparatus. The holder of the fellowship must devote a year to research in some subject connected with the gas industry.

Asaph Hall, Jr., Professor of Astronomy, has recently been appointed a member of the board of visitors for the Naval Observatory at Washington.

THE BARSCHALL RAIL JOINT ON THE PENNSYLVANIA RAILROAD.

We illustrate in the accompanying drawings the details of the Barschall rail joint, which is now being tested on several sections of the Pennsylvania railway system. As many of our readers know, this joint is of European invention and comes to this country with a very favorable record of successful use on the continent. In principle the joint differs from all others which have been used in the United States, in that it depends upon an independent auxiliary rail to carry the wheels over the rail joints instead of upon a stiff spliced connection alone. The location and operation of this auxiliary rail are clearly shown by the accompanying drawings. Up to the present time no records of the experience of the Pennsylvania company with the new joint are available. The claims made for the joint and the experience upon which they are based are stated in a letter to us from Mr. Charles Barschall, of the Barschall Impregnating Co., of New York city, which controls the device in this country, as follows:



DETAILS OF BARSCHALL RAIL JOINT BEING TESTED ON THE PENNSYLVANIA R. R.

European experience has shown that the only joint that will prevent hammering is one with a wheel-carrying auxiliary rail. Whenever wheel-carrying joints have been a failure it has been due to incorrect construction. The Royal R. R. of Saxony, which has made the most extensive and thorough tests, has experienced such favorable results that it has equipped its lines with a wheel carrying fish-plate ("Auflauflasche"). The "Kopflasche," being cut into the rail ends so as not to alter the running width at the joint, had been tried previously, and had given favorable results, but the objection to cutting the rail ends and the consequences thereof, prevented its adoption. The "Auflauflasche" is superior and its general adoption in Saxony more than five years ago was the first proof that the theory against the wider running surface is in fact not correct. The Prussian Royal R. R. has tested a similar "Auflauflasche" and the "Stossfangschiene" (Barschall Rail Joint), each on about 20 miles of track. The observations of nine years have shown that the Barschall joint is by far superior, and the trial stretches put in in foreign countries, and in this country, have been due to this favorable experience and the warm recommendations of the Prussian engineers who had the tests under their observation. The Vienna R. R., the Kaschau Oderberger Bahn, the Mecklenburg Friedrich Franz Bahn, have since 1896 used rolled Barschall joints. These have proven superior to those cut out of rails, because the rolled section of the outer rail has a running surface which sets closer to the main rail; that is to say, the running surface at the joint is narrower.

The principles of construction of the Barschall rail joint (independent support of the outer rail, shape of filler and fastening) are generally recognized in Europe as superior to all others. Some questions about increasing the efficiency of the joint remain, however, to be solved by practical service; such as the proportionate length of the longitudinal slopes and the running surface of the outer rail, and depending on it, the spacing of the joint ties. The rail ends must be protected by the running surface of the outer rail, at the point where they now begin to be hammered down. This decides the necessary length of its bearing surface. As the narrow and rounded bearing surfaces of the filler allow a limited independent movement of the two supports (main rail and auxiliary rail), it may be desirable to make the largest use of this circumstance, by beginning the full width of bearing surface of the outer rail not over the tie-plate, but about at its end. The deflection of the outer rail, where it is suspended, will by these means insure smooth running of even badly-worn flanges and reduce to a minimum the wear of the outer rail. Some experts have made the claim that new wheels will be supported by the main rail only and not by the outer rail. This is not the case under a rolling load, on account of the deflection of the main rail which brings into action the outer rail. The limit of the independent movement of the two supports is easily seen with joints applied to rails with hammered ends. The wheels will be supported by the outer and the main rail, if the latter has not been hammered down beyond the limit of this independent movement; if it has, the outer rail will carry the load alone over the joint, and protect the ends until the maximum wear of the entire length of rail is obtained. If in some exceptional cases of badly-worn tires the false flanges should cause a perceptible shock, this is certainly no objection in comparison to all wheels hammering on all joints. There is no doubt of a considerable saving on rolling stock by doing away with this hammering. The saving on rails, and the whole superstructure, as well as in maintenance of tracks, have been demonstrated by experience, and large immediate savings can be made by equipping rails with hammered ends with the joint instead of renewing the rails, which will then last until worn out throughout their entire length.

PRIMARY TRIANGULATION AND PRECISE LEVELS OF THE UNITED STATES GOVERNMENT SURVEYS.*

By Herbert M. Wilson.†

The surveys made for the topographic mapping and for the charting of the coast of the United States have been prosecuted over widely separated portions of the country. It was therefore necessary that they should be based upon some common datum for both horizontal and vertical reference in order that the separate charts and maps should connect exactly, one with the other. It is evident that this would be impossible had the surveys been based on ordinary traverse lines by transit and chain. The results would have failed to connect over a state or even county. The roads mapped by surveys commenced in the eastern part of a state would have failed to join those brought through by surveys commenced in its western end by one or more miles.

The fundamental base adopted for horizontal control is astronomic position; that for vertical control is mean sea level. The former is obtained by careful astronomic observations at widely scattered points, to determine the latitude and longitude of an initial position and the azimuth of a line. Initial distances are determined at intervals of 200 to 400 miles by base lines of from four to six miles in length measured with the greatest care and by the most accurate known methods. The lengths of these bases are expanded by means of a system of triangulation, the result of repeated measures of the three angles of each triangle, the length of one side of which, the base, is known. Gradually a series of triangles is extended until two systems of triangulation depending on separate bases meet in a common side. In this manner the entire area of the United States will be ultimately grid-ironed from coast line to coast line with a network of geodetic triangulation. The accuracy of the measurement of this is such that the length of any side or the astronomic position of any apex will be located with a probable error of a few feet at the most, an amount which is unappreciable upon the scales of the resulting maps.

Occasionally the conditions are unfavorable to the execution of triangulation, as when the surface of the land is flat and wooded and devoid of prominent points from which to observe angles. In such cases the primary control consists of traverse lines measured by steel tape with nearly as great accuracy as a base line, and these are frequently connected with astronomic positions or with primary triangulation locations, and are further checked by numerous determinations of azimuths.

Dependent upon this general scheme of primary horizontal control are secondary and tertiary schemes of triangulation or traverse executed by instruments and methods of less precision. The result of the whole is a minute network of triangulation and traverse positions covering the entire area which is to be mapped, the whole executed with various degrees of accuracy, according as they are nearer the initial astronomic stations or to the details of the topographic map. Each unit thereof is executed with only such accuracy that errors propagated through the following operations shall be kept within such limits that the ultimate positions, upon which the topographic map is based, shall not be in error by an amount appreciable on its scale.

The three great surveying organizations of the government, the Coast and Geodetic Survey, the Geological Survey and the Engineer Corps of the Army and its allied commissions, are all engaged in extending systems of primary triangulation upon which to base their charts and maps. Widely as their operations ramify throughout the area of the country there is no duplication of work in any part. The results of the field work of each organization are immediately available for the use of the others. The Coast and Geodetic Survey has already carried a chain of triangulation around the entire coast line of the United States as a base for its charts. It has also extended a system of triangulation of the greatest geodetic refinement into several coastal states and a great belt of transcontinental tiangulation connecting the Atlantic and Pacific coasts that the relations of the two may be closely united. The Engineer Corps has extended a system of triangulation around the entire shore lines of the Great Lakes and throughout the lengths of the Mississippi and Missouri rivers as a base for the charts of their waters.

The Geological Survey has utilized this and similar geodetic material as a base for its topo-

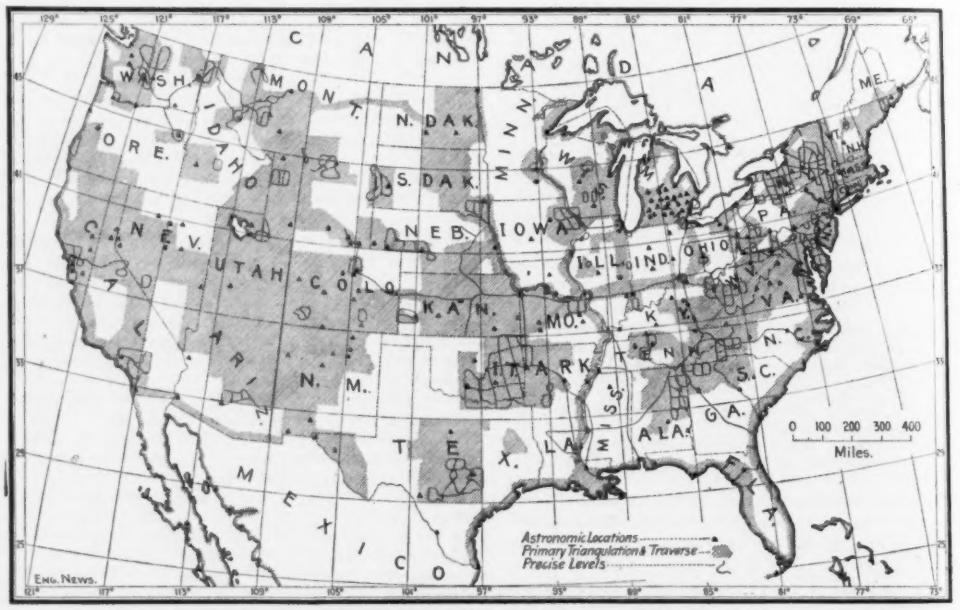


FIG. 1.—SKETCH MAP SHOWING PROGRESS OF PRIMARY TRIANGULATION AND SPIRIT LEVELING; U. S. GOVERNMENT SURVEYS.

*A previous article on "Topographic Mapping" was published in our issue of Feb. 7.

†U. S. Geological Survey, Washington, D. C.

graphic mapping, and where such did not exist it has extended triangulation over areas to be mapped. Finally, a number of minor organizations have extended triangulation for special purposes, the most important of these being the Town Boundary Survey, which is covering the state of Massachusetts with triangulation of high accuracy, and the old State Survey of New York, which extended triangulation over a large part of the area of that state. Also there is the International Boundary Survey between the United States and Mexico, and other surveys of lesser magnitude.

The distribution of this work is indicated upon the accompanying progress map, Fig. 1, and the areas of states covered by primary control are shown upon the accompanying diagram, Fig. 2. The existing primary triangulation and traverse covers a total area of 1,312,000 square miles or

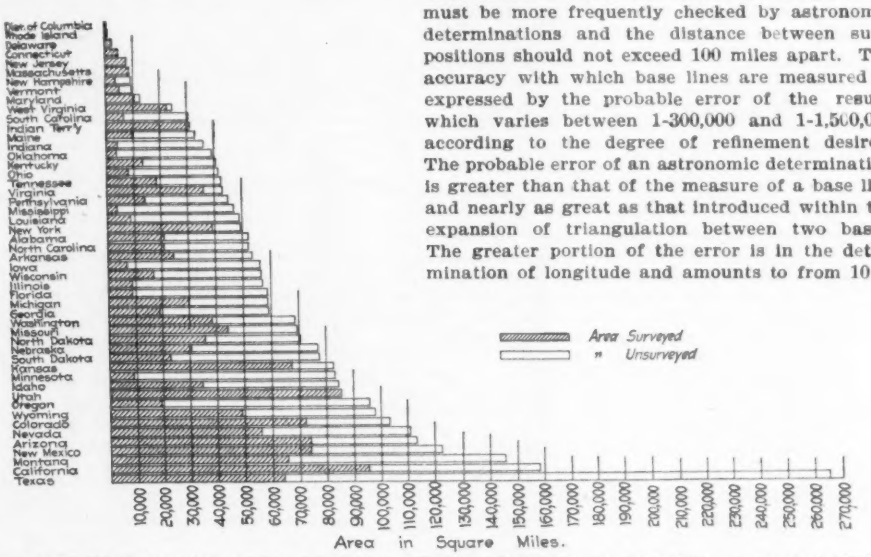


FIG. 2.—DIAGRAM SHOWING AREA OF EACH STATE COVERED BY PRIMARY TRIANGULATION; U. S. GOVERNMENT SURVEYS.

43% of the area of the United States. On the map are also shown the location of astronomic positions.

In the earlier days of these surveys the positions occupied were not well marked, excepting in a few scattered instances. During the last quarter century the positions of the Coast Survey and Engineer Corps have been well marked, and during the last decade the positions determined by the Geological Survey have been equally well marked. This marking consists usually of stones or tablets buried underground, surface marks being stones or iron posts usually buried for two or three feet with a half foot or more projecting, the exposed portion being suitably inscribed. Where surface rock is exposed copper bolts or tablets have been inserted and properly stamped.

The result is a great number of accurately determined positions which will be ultimately scattered over the entire surface of the country at distances of 10 to 30 miles apart. On these will undoubtedly be based in the course of time all cadastral surveys. To them will be tied by similar schemes of triangulation the boundary lines separating states and, ultimately, those separating counties and towns, as is now being done in Massachusetts. With them will also be connected private property lines, as property comes to be of greater value, as has been done in the public land surveys of the Indian Territory. In Europe and India all of the cadastral surveys down to the most minute property divisions are being rapidly controlled by systems of geodetic triangulation.

Boundary lines which are based upon geodetic triangulation can never be lost, since it is always possible to go back to some triangulation station which can be recovered, from which angles can be quickly repeated in accordance with the published notes, thus resulting in the re-establishment of the lost position and the recovering of the lost land marks. Accordingly as property becomes more valuable with time, its boundaries will be more clearly defined and vexatious law suits will diminish in number. The various government bureaus engaged in this work publish the positions as rapidly as they are determined and keep on file records of their descriptions.

The scope of this article precludes the possibility of entering into details of field or office work by which primary triangulation or traverse are executed. The methods are published in the numerous reports issuing from the various government bureaus as well as in text books on topographic and geodetic surveying. In general they may be briefly characterized as follows:

Base lines and the astronomic positions of one of their extremities are located with only such nearness one to the other as is necessary to check the accumulated errors of the system of connecting triangulation. This is at distances of 250 to 400 miles apart. Primary traverse, being far more liable to errors than primary triangulation, must be more frequently checked by astronomic determinations and the distance between such positions should not exceed 100 miles apart. The accuracy with which base lines are measured is expressed by the probable error of the result, which varies between 1-300,000 and 1-1,500,000 according to the degree of refinement desired. The probable error of an astronomic determination is greater than that of the measure of a base line and nearly as great as that introduced within the expansion of triangulation between two bases. The greater portion of the error is in the determination of longitude and amounts to from 10 to 15 ft. in distance in the best work. The probable error of an expanded scheme of triangulation is from 1-300,000 to 1-500,000. In primary traverse the probable error in a distance of 100 miles varies from 1 in 5,000 to 1 in 50,000, or from 10 to 100 ft., this class of work being evidently much less accurate than the other varieties of geodetic work.

The operation of determining an astronomic position consists, first, in the measurement of zenith distances of stars by means of delicate transit instruments for the determination of latitude; second, the exchange of telegraphic time signals between a known astronomic position and an unknown one for the determination of time difference, and hence the difference of longitude; and, third, the determination by astronomic observation on close circumpolar stars of the azimuth of a line, presumably a base line or side of a triangle. The measurement of a base line consists, first, in the selection of a site, the extremities of which are so situated as to permit of easy expansion by primary triangulation; second, the laying out of a site by running a line of spirit levels over it and of setting plugs or other stable measuring marks at fixed intervals; third, the ranging out of a straight line by transit or theodolite; and finally, the measurement of the length of the base by means of base bars, iced bars or steel tapes. The expansion of a system of primary triangulation consists: first, in a reconnoissance to select stations from which others are intervisible in such manner as to permit of the formation of a series of quadrilateral, pentagonal, or similar figures composed of well-conditioned triangles; second, the erection of signals and the marking of station positions by monuments; and, third, the measurement of the angles at any one station to the others which are intervisible therefrom, by means of theodolites of high power. Finally, there remains the office computation whereby the lengths of the sides of the various triangles are determined, and by the aid of this and their connection with a known astronomic position and azimuth the geodetic position and co-ordinates of the various triangulation stations are computed. These or equivalent co-ordinates at important points on a traverse line are then platted on the topographic map sheets, and this furnishes the primary control for the extension of the secondary detail of the map.

The datum on which all of the representation of relief by contours is based is mean sea level. In order that pieces of work separated by distances of 100 or 1,000 miles may ultimately meet on sheet lines with homogeneity of vertical location, it has been necessary, first, to plan out series of precise levels similar to the systems of primary triangulation for the control of the whole. These precise levels are connected with tidal gages referred to the mean level of the sea. With these primary data in existence it is possible to commence field work in widely-scattered areas, lines of spirit leveling of lesser precision being run throughout the area to be mapped at distances not exceeding six miles apart. Between these, at distances of one to three miles apart, according to the scale and contour interval, lines of flying or secondary levels are run with only such accuracy as will enable them to close upon the better levels within limits of 1 or 2 ft., an amount imperceptible in contours of 10 to 50 ft. interval.

The three surveying bureaus of the government are engaged in running lines of precise levels throughout the country, as they are the related work of extending primary triangulation and topographic mapping. The Coast and Geodetic Survey has established tidal gages for the determination of the position of mean sea level at numerous points on the Atlantic and Pacific coasts. The Army Engineers have done the same on the Great Lakes. The Coast Survey has run lines of precise levels from Sandy Hook up the Hudson River to Albany; also from Sandy Hook via Harrisburg, Grafton and Cincinnati to St. Louis. This transcontinental line has been extended via Denver to beyond Cheyenne, its present terminus. The Coast Survey has also run lines of precise levels from the Gulf of Mexico to St. Louis, and from an Army Engineer's bench mark at Toledo via Cincinnati to Chattanooga, where connection was made with the levels of the Geological Survey, and thence to connection with the Army Engineer's bench mark at Birmingham.

The Army Engineers have run levels from the Coast Survey bench mark at Albany to the northern boundary of New York, and thence southeastward along the St. Lawrence to tide gages on Lake Ontario; also from Albany along the Mohawk Valley to Lake Ontario. The Great Lakes are connected by tidal observations and short connecting links of levels. They have also run lines of levels from the mouth of the Mississippi up that river to St. Paul and Duluth; also to Chicago, and from St. Louis up the Missouri to Sioux Falls; and up the Red and Arkansas rivers.

The Geological Survey has run lines of precise levels from Beaufort, N. C., via Asheville and Chattanooga to Atlanta; also from Brunswick, Ga., to Atlanta; also throughout various portions of the states of New York and Pennsylvania; also from Puget Sound and the mouth of the Columbia River to Spokane, Missoula and Helena, Mont. It is thus seen that the half of the United States which lies east of the Missouri and Mississippi rivers has been thoroughly grid-ironed with connected systems of precise levels. These are tied to mean sea level at eight important points between Boston and the mouth of the Mississippi.

There have also been run numerous levels of lesser precision, but of much greater accuracy than those of ordinary railway or canal levels. These are chiefly, the precise levels of the Massachusetts Topographic Commission, from Boston to Albany; the precise levels of the Pennsylvania Railway via Harrisburg, Pittsburg and Fort Wayne to Chicago; the precise levels of the New York Central Railway. Finally, there is the great mass of primary levels run by the Geological Survey wherever its topographic mapping is being extended.

As an indication of the accuracy attainable in precise leveling it may be stated that between five determinations of the height of the St. Louis Directrix, there is an extreme variation of about 1.05 ft. The Gristmill bench mark at Albany is determined with less certainty by three separate

lines, with an extreme limit of error of about 1.5 ft., and a probable mean error of about 0.5-ft. Our knowledge of the heights of various points, as determined by precise leveling, is rapidly changing from day to day as the various systems of levels are extended, so that the time is not far distant when the heights of various important bench marks will be known within reasonable limits of error. During the current year two new lines of levels have been run by the Geological Survey connecting to the Gristmill bench mark, and two lines have been run by the New York Central R. R. It is likely that when these have been adjusted the height of the Gristmill bench mark will be lowered about 0.5-ft., and will be established with reasonable accuracy. Likewise levels of the current year by the Coast Survey between Toledo, Cincinnati, Chattanooga and Birmingham make important checks between mean sea level and the lines leading to the St. Louis Di-

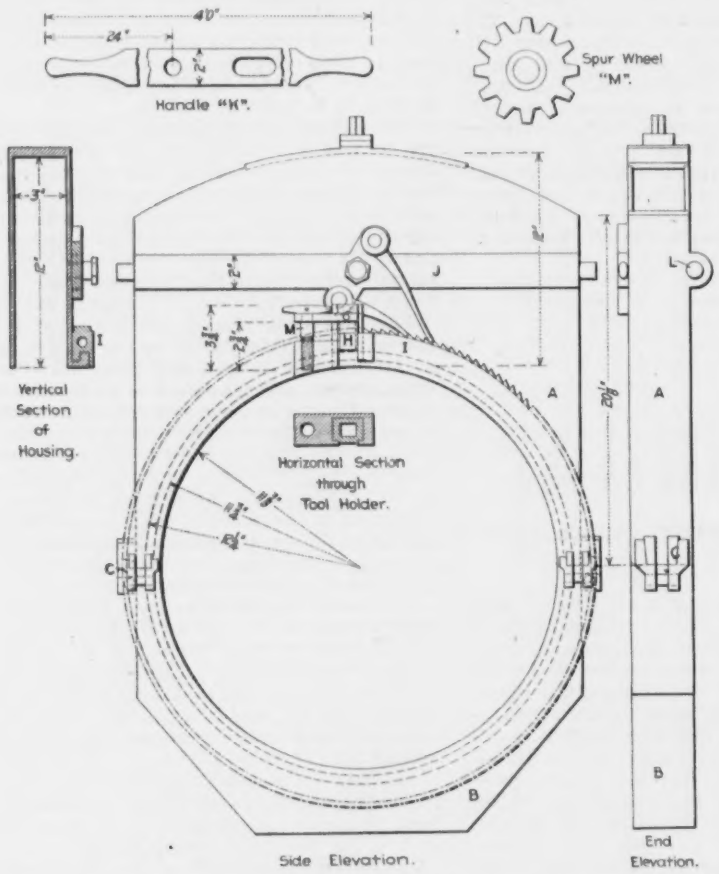


FIG. 1.—SIDE AND END ELEVATIONS OF PIPE-CUTTING MACHINE.
Invented by J. J. Rigney, Shamokin, Pa.

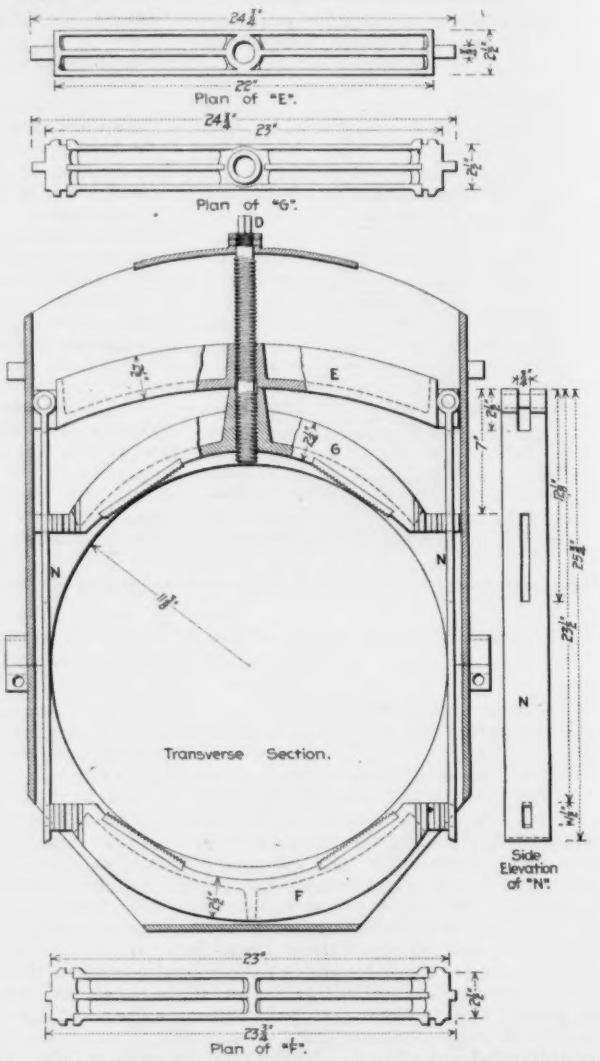


FIG. 2.—SECTIONAL SIDE ELEVATION OF PIPE-CUTTING MACHINE.

rectrix, which will, when adjusted, give a far better determination of the height of that bench mark than that now accepted. Within two or three years the connection between the Atlantic and the Pacific by the Transcontinental line of the Coast Survey will be completed.

The number of miles of levels which have been run by organizations other than the Geological Survey are difficult to determine with accuracy. The Coast Survey has run about 6,000 miles of precise levels. The Army Engineers have run, exclusive of about 1,000 miles of water levels between tidal gages on the Great Lakes, about 5,000 miles of precise levels. The precise levels of the Pennsylvania and New York Central railways aggregate about 2,000 miles. The precise levels of the Geological Survey have a length of about 3,000 miles, and their primary levels, which have nearly the value of precise levels, aggregate 58,000 miles in length. The primary levels run by the Geological Survey during the past five years have averaged 12,000 miles per annum, which may be taken as the speed with which these levels will be extended during the future. In the course of these levels permanent bench marks have been set every 3 to 6 miles over the entire 160,000 square miles mapped since 1896.

The routes of the precise and primary leveling of the various organizations are published in Annual Reports of the Geological Survey, the Coast Survey and of the Chief of Engineers of the Army. Descriptions and elevations of any of the bench marks established by these organizations can be procured by correspondence with those offices. It is thus evident that the results of this important work are being rapidly developed and adjusted in such manner as to make them most serviceable in connection with all engineering work in the United States. Already demands from engineers for information of this character are of such amount as to bring daily communications to one or other of these bureaus asking descriptions and heights of bench marks. The civil engineers of the country have already found that they may thus be saved much of the time and expense of rerunning check levels, it being only essential that they start from one of the bench marks of the Federal Government and extend their work but a short distance beyond its terminus to a closure on another, when a check on the accuracy of their results is had.

A NEW PIPE-CUTTING MACHINE.

To cut off a cast-iron water or gas main exposed in a deep trench is a rather tedious and clumsy operation, especially if it must be done with the aid only of hack-saw, hammer and chisel. In our issue of March 29, 1894, we described a machine designed to accomplish this in an efficient and expeditious manner and we herewith present drawings of another machine devised for the same purpose. This machine, like the one previously described, operates in much the same way as a lathe, except that the tool travels around the work and the latter remains stationary.

Side and end elevations of the machine are shown in Fig 1. The housing, which encircles the pipe, is made in two parts A and B, which are joined on either side by locks at C C. When one of the housing has been locked about the pipe it is made to grip the latter tightly by means of the arrangement shown in the sectional side elevation in Fig. 2. Turning the screw D pulls up the yoke E and F, which are connected by the bars N N and forces down the yoke G, setting the teeth in G and F against the pipe. The toolholder H is attached to the ring I, which is split diametrically and provided with devices for locking together. It slips in a circular groove upon the two parts of the housing, as may be seen in Fig. 1. The outside of the ring is provided with teeth, upon which act ratchets attached to the lever J. The latter is given an oscillating motion by means of the handle K, which operates with the lug L as a fulcrum. The handle may be attached to the machine on either side and it will be noted that it always stands parallel to the pipe. The tool is fed into the work by the screw M, the toothed head of which engages a short rack once in each revolution.

A representative of this journal was present at a test of this device made recently by the Water Department of New York city. A piece of very hard cast-iron pipe about 10 ins. in diameter was cut off in a short time. The machine was then provided with a special tool and used to remove the lead calking from a joint. For this purpose a special sidewise feeding device is provided. The machine exhibited would work upon any size of pipe between 6 and 10 ins. in diameter.

The drawings presented herewith were furnished by Mr. J. J. Rigney, of Shamokin, Pa., who is the inventor of the machine.